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STOPPING WATER POLLUTION AT ITS SOURCE

MISA

Municipal Industrial Strategy for Abatement

THE EFFLUENT MONITORING PRIORITY POLLUTANTS LIST

(1987)

Environment
Ontario

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THE EFFLUENT MONITORING PRIORITY POLLUTANTS LIST (1987)

Report prepared by:

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Ontario Ministry of the Environment

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1.0 EXECUTIVE SUMMARY

This report outlines a chemical hazard assessment methodology for the on-going development of an Ontario Effluent Monitoring Priority Pollutants List (EMPPL). This hazard assessment is based on a chemical's environmental persistence, potential to bioaccumulate, acute and sub-lethal toxicity to biological organisms including humans, and potential to exist in effluents discharged to surface waters.

This report also identifies 179 chemicals or groups of chemicals which constitute the 1987 version of the Effluent Monitoring Priority Pollutants List. The list represents those chemicals that have been detected or are potentially present in Ontario municipal and industrial effluents and pose a hazard to the receiving environment. It provides a sound basis on which to initiate development of chemical specific monitoring regulations under the MISA program. In total, over 1500 chemicals were considered.

Open characterization and monitoring of Ontario effluents will assist in identifying effluent constituents, and will eliminate the reliance on data from other jurisdictions which may not be representative of discharges in Ontario.

A permanent federal-provincial advisory committee (Priority Substances Advisory Committee) has been established. A major function of this committee is to provide advice for the addition/deletion of chemicals as new information on effects, environmental fate and exposure becomes available.

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1.0 INTRODUCTION

In June 1986, the Ontario Ministry of the Environment released a paper entitled "Municipal-Industrial Strategy for Abatement (MISA)", which described a program for protecting Ontario's water quality. MISA's ultimate goal is the virtual elimination of toxic chemicals discharged to surface waters. Meeting this goal will reduce the risk of damage to the ecosystem and will protect public health by minimizing the presence of toxics in ambient and drinking water, fish and wildlife (40).

To facilitate the management of the various chemicals present in the environment, both industrial and municipal effluents are being characterized for toxic chemicals. As this is being accomplished, monitoring regulations are established for each industrial sector and for municipally and provincially operated sewage treatment plants.

A federal-provincial multi-disciplinary MISA Priority Pollutants Task Force was established in October of 1986 to assist in the development of monitoring regulations. The Task Force was specifically charged with identification and listing of those chemicals potentially present in industrial or municipal effluents in Ontario which could pose a hazard to the receiving environment. This list is known as the Effluent Monitoring Priority Pollutants List. A draft report was released for public review in August 1987. The public comments received were considered in finalizing this report. Detailed responses to the public comments are provided in the Ministry's publication, "The Public Review of the Draft Effluent Monitoring Regulations for the Petroleum Refining Sector and the Ministry of the Environment Response to it".

2.0 PRINCIPLES USED IN THE DEVELOPMENT OF THE 1987 ONTARIO EFFLUENT MONITORING PRIORITY POLLUTANTS LIST (EMPPL)

A number of principles were followed in the development of the EMPPL. These were:

1. To develop state-of-the-art criteria and procedures for the identification and hazard assessment of chemicals;

2. To use wherever possible, the results of previous Ministry of the Environment (MOE) efforts in the areas of chemical identification and chemical hazard assessment; and also to use relevant methodologies and chemical assessments developed by other regulatory agencies that are generally accepted by the scientific and regulatory communities;

3. To use information currently existing in the scientific literature to the greatest extent possible and to ensure that all information used becomes part of the public domain; and

4. To ensure that the methodology and the resulting EMPPL can be easily modified and updated as new information becomes available.

3.0 APPROACH USED FOR DEVELOPMENT OF THE 1987 EMPPL

The chemical hazard assessment methodology used was adapted from recent Ministry undertakings and from similar programs in other jurisdictions. This methodology assessed environmental and human health effects and the potential presence of hazardous chemicals in Ontario industrial and municipal effluents.

The assessment methodology used was a two-stage process consisting of a chemical identification stage and a preliminary hazard assessment stage (see Figure 1).

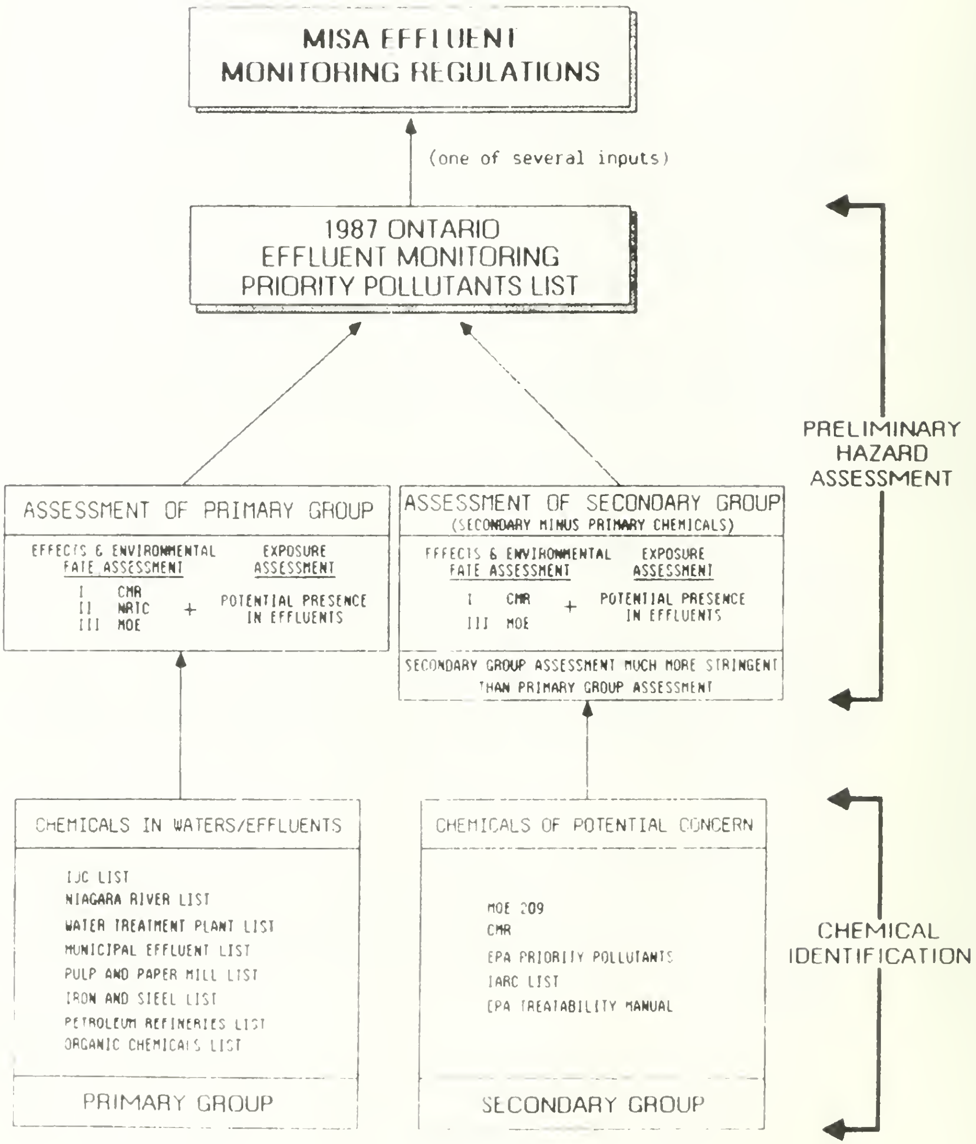
3.1 CHEMICAL IDENTIFICATION

The first step was to develop a comprehensive list of candidate chemicals. Primary and secondary chemical groups were compiled from chemical lists gathered by agencies or organizations (listed below) that have chemical assessment and regulatory responsibilities. Over 1500 chemicals were identified and these are on file with the Ministry.

3.1.1 Primary Group

The primary group consists of chemicals which have been detected in the Great Lakes or in industrial and municipal effluents.

FIGURE 1
APPROACH USED FOR THE DEVELOPMENT
OF THE 1987 EMPPL


MISA EFFLUENT MONITORING REGULATIONS
(one of several inputs)
1987 ONTARIO EFFLUENT MONITORING PRIORITY POLLUTANTS LIST
PRELIMINARY HAZARD ASSESSMENT
ASSESSMENT OF PRIMARY GROUP
EFFECTS & ENVIRONMENTAL FATE ASSESSMENT
I CMR
II NRTC
III MOE
+
EXPOSURE ASSESSMENT
POTENTIAL PRESENCE IN EFFLUENTS
ASSESSMENT OF SECONDARY GROUP
(SECONDARY MINUS PRIMARY CHEMICALS)
EFFECTS & ENVIRONMENTAL FATE ASSESSMENT
I CMR
III MOE
+
EXPOSURE ASSESSMENT
POTENTIAL PRESENCE IN EFFLUENTS
SECONDARY GROUP ASSESSMENT MUCH MORE STRINGENT THAN PRIMARY GROUP ASSESSMENT
CHEMICALS IN WATERS/EFFLUENTS
IJC LIST
NIAGARA RIVER LIST
WATER TREATMENT PLANT LIST
MUNICIPAL EFFLUENT LIST
PULP AND PAPER MILL LIST
IRON AND STEEL LIST
PETROLEUM REFINERIES LIST
ORGANIC CHEMICALS LIST
PRIMARY GROUP
CHEMICALS OF POTENTIAL CONCERN
MOE 209
CMR
EPA PRIORITY POLLUTANTS
IARC LIST
EPA TREATABILITY MANUAL
SECONDARY GROUP
CHEMICAL IDENTIFICATION

NOTE: REFER TO SECTION 3.1 FOR DEFINITION
OF ACRONYMS AND FOR LIST DESCRIPTIONS

Specifically, the primary group was drawn from:

- IJC Inventory of Chemicals Identified in the Great Lakes Ecosystem (see Ref. 11)

  This inventory consists of those chemicals identified in the Great Lakes Basin by the International Joint Commission (IJC).

- Niagara River List (see Ref. 12)

  This is a list of chemicals identified by the Niagara River Toxics Committee.

- Water Treatment Plant Intake List (see Ref. 10)

  This list identifies those compounds which have been detected, on at least one occasion, in raw water samples taken at water supplies currently being monitored in Ontario's Drinking Water Surveillance Program.

- Municipal Effluent List (see Ref. 4)

  This list of chemicals was extracted from a review of hazardous contaminants found in American and Canadian sewage treatment plant effluents and sludges. Only those chemicals identified in Ontario based sewage treatment plant effluents were included.

- Pulp and Paper List (see Refs. 3, 45, 46)

  This list presents the results of investigations by the Ontario Ministry of the Environment and a federally funded study performed by B.C. Research to characterize Canadian pulp and paper mill effluents.

- Iron and Steel List (see Ref. 2)

  Chemicals identified on this list are found in effluents from both the American and Canadian iron and steel industry. Chemicals identified by MOE monitoring are included in addition to those chemicals expected to exist at quantifiable levels in effluents from Ontario based iron and steel plants.

- Petroleum Refineries List (see Ref. 1)

  This list includes data on chemicals in Ontario petroleum refinery effluents.

- Organic Chemicals List (see Refs. 5, 6, 7, 8, 9)

  This list comprises chemicals characterized in the organic chemical industry discharges in the Sarnia and Cornwall vicinities. The data were primarily from the St Clair River MISA pilot site investigation and augmented with additional data from Environment Canada and Ministry of the Environment surveys.

3.1.2 Secondary Group

There was concern that hazardous chemicals may be present in Ontario effluents which have not yet been identified in environmental or effluent samples in Ontario or in the Great Lakes. A number of source materials were used to identify these chemicals. Some chemicals were common to both groups: those chemicals already identified in the primary group were not included in the secondary group. Specifically, the secondary group was drawn from the following sources:

- MOE 209 List (see Ref. 13)

  This publication lists 209 chemicals or chemical classes that were identified by the Ontario Ministry of the Environment as being of particular environmental and human health concern.

- Michigan Critical Materials Register (CMR) (see Ref. 18)

  The Michigan Water Resources Commission is authorized by law to develop a Critical Materials Register listing that are or may be used and/or discharged in Michigan. Chemicals on this list are reviewed and rated for acute toxicity, carcinogenicity, hereditary mutagenicity, teratogenicity, persistence, bioaccumulation and other adverse effects.

° U.S. EPA Priority Pollutants List (see Ref. 16)

The U.S. EPA Priority Pollutants List includes a total of 126 chemicals or chemical groups. The list was first established under an agreement (court consent decree) between the U.S. EPA and the Natural Resource Defence Council in 1976. The U.S. EPA is required, under this agreement, to establish water quality criteria, effluent guidelines and pretreatment requirements for the compounds on the Priority Pollutants List.

° IARC List (see Ref. 19)

In 1982, an ad hoc Working Group of the International Agency for Research on Cancer (IARC) considered all evaluations published in IARC monographs volume 1-29 to determine which chemicals, industrial processes and industries could be considered carcinogenic to humans. The substances and processes were grouped as follows:

Group 1: causally associated with cancer in humans;
Group 2A: probably carcinogenic to humans with limited human evidence;
Group 2B: probably carcinogenic to humans with inadequate evidence of carcinogenicity to humans;
Group 3: could not be classified as to their carcinogenicity to humans.

° U.S. EPA Treatability Manual (see Ref.14)

This manual provides data on the treatability of chemicals and chemical groups known to be present in U.S. industrial waste waters.

3.2 PRELIMINARY HAZARD ASSESSMENT

3.2.1 Assessment Criteria and Process

This section discusses the process in terms of (a) assessment of effects and environmental fate; (b) assessment of exposure; and, (c) the method used for promoting chemicals to the EMPPL.

(a) Effects and Environmental Fate Assessment

Selected existing methodologies, summarized below, were adapted to carry out the effects and environmental fate assessment. An in-depth description of each methodology is provided in Appendix A.

I. State of Michigan, Department of Natural Resources, Environmental Services Division, Critical Materials Register (CMR), 1980

The CMR chemical assessment methodology is used by the State of Michigan to assess the potential hazard of a large number of chemicals. The primary and secondary groups were reviewed and those chemicals that had been assessed for the CMR were identified. Chemicals were assessed using the following parameters:

- Persistence
- Bioaccumulation
- Acute toxicity
- Hereditary mutagenicity

- Teratogenicity
- Carcinogenicity
- Other adverse effects

Since these characterize the inherent properties of a chemical, the concern levels attributed to each of the above cited parameters by the State of Michigan were considered suitable for use in Ontario.

II Niagara River Toxics Committee (NRTC)

The Niagara River Toxics Committee assessed a large number of chemicals detected in the Niagara River. Assessments by the NRTC were accepted only for those primary group chemicals that had not been assessed for the CMR.

These assessments were based on presence in the environment, guidelines and standards developed to protect human health and the environment, acute aquatic and mammalian toxicity, bioaccumulation and human health assessments undertaken by the IJC Human Health Effects Committee.

III Ministry of the Environment, Priority List Working Group (MOE)

The remaining chemicals in the primary and secondary groups were reviewed by the Task Force. Selected chemicals were assessed by the consulting firm MacLaren Plansearch Inc., using criteria developed by the Priority List Working

Group. The Priority List Working Group was responsible for developing and implementing a methodology for assessing the relative environmental hazards of chemicals. The primary objective of the Working Group was to identify chemicals for multi-media standards development.

The consultants evaluated the following parameters:

- Persistence
- Bioaccumulation
- Acute lethality
- Sublethal toxicity - Non-mammalian
- Sublethal toxicity - Plant
- Sublethal toxicity - Mammalian
- Mutagenicity/Genotoxicity
- Teratogenicity
- Carcinogenicity

In general, these assessments were based on information readily available in the open literature.

On the advice of the MISA Priority Pollutants Task Force, when it was believed that use of the most current data would lead to a significantly different hazard assessment, certain chemicals which had been previously assessed for the CMR or the NRTC report were re-assessed using the MOE method.

(b) Exposure Assessment

A method was developed for the assessment of human and environmental exposure to chemicals based on a chemical's presence in effluents and in the environment, as well as use/manufacture and potential discharge from industrial processes.

(c) Promotion to the EMPPL

The parameter scores for both exposure and effects assessments determined if the chemical was placed on the EMPPL.

Tables 1 and 2 list the parameters for both the effects and environmental fate assessment and the exposure assessment that promoted a chemical to the 1987 list.

For a chemical to be promoted to the EMPPL from the primary group (see Table 1), the parameter score for at least one parameter must be equal to or greater than the concern level used for the CMR assessment; or be identified as a Group I, IIA or IIB chemical by the NRTC; or the parameter score for at least one parameter must be equal to or greater than the concern level used for the MOE assessment. In addition, the chemical must be classified as "A" or "B" in terms of its exposure.

For a chemical to be promoted to the EMPPL from the secondary group (see Table 2), the parameter score for at least one parameter must be equal to or greater than the concern level used for the CMR assessment; or the parameter score for at least one parameter must be greater than or equal to the concern level used for the MOE assessment. In addition, the chemical must be classified as "A", "B", or "C" in terms of its exposure.

The secondary group contains those high priority chemicals that, if present in Ontario effluents, would be hazardous to the receiving environment. Higher criteria were assigned for chemicals in the secondary group than for those in the primary group because the secondary group consists of a large number of chemicals for which effects information is available but Ontario exposure information is limited. MacLaren Plansearch provided exposure information on these chemicals.

Chemicals which would have been promoted from the primary and secondary groups solely due to persistence but had low concern levels for toxicity and bioaccumulation were excluded from the EMPPL.

3.2.2 Rationale for Exclusion of Pesticides and Pharmaceuticals

Pesticides may appear in industrial and municipal effluents due to their presence in industrial intake water and in the influent to sewage treatment plants.

TABLE 1: PROMOTION FROM THE PRIMARY GROUP TO THE EMPPL

EFFECTS AND ENVIRONMENTAL FATE ASSESSMENT

I CMR - If any of the concern levels are met for any of the parameters and the exposure is classified as an A or B the chemical is promoted (see Appendix 1 for detailed description of the CMR)

Parameter	Concern Level*
Persistence	≥ 1
Bioaccumulation	≥ 3
Acute Toxicity	≥ 3
Other Adverse Effects	≥ 3
Hereditary Mutagenicity	≥ 4
Teratogenicity	≥ 3
Carcinogenicity	≥ 2

II NRTC - If the chemical is listed on groups I, IIA or IIB and its exposure is classified as an A or B, then it is promoted (see Appendix 1 for detailed explanation of the NRTC ranking)

Group I	cited as requiring immediate attention, and recommended for source testing
Group IIA	cited as presenting potential health hazards
Group IIB	cited as being of concern from a human health perspective

III MOE - if any of the concern levels are met for any of the parameters and the exposure is classified as an A or B the chemical is promoted (see Appendix 1 for detailed description of the MOE assessment method)

Parameter	Concern Level*
Persistence	≥ 7
Bioaccumulation	≥ 7
Acute Lethality	≥ 6
Sub-Lethal Toxicity Non-Mammalian	≥ 6
Sub-Lethal Toxicity Plant	≥ 6
Sub-Letnal Toxicity Mammalian	≥ 6
Mutagenicity/Genotoxicity	≥ 6
Teratogenicity	≥ 2
Carcinogenicity	≥ 2

EXPOSURE ASSESSMENT - Potential Presence in Effluents ≥ B

A - almost "always" present
- >50% detection and minumum of 5 data points

B - potentially present in Ontario
- detected in effluent or reported as being discharged
- detected in the natural environment and probable Ontario use/manufacture

C - inferred to be present in a process aqueous discharge and probable Ontario use/manufacture

D - possibly present based on use/manufacturing information only

E - not present - based on analytical data and/or inference from the literature

* CMR and MOE numerical values were assigned to represent equivalent concern levels between the two hazard assessment methods

TABLE 2: PROMOTION FROM THE SECONDARY GROUP TO THE EMPPL

EFFECTS AND ENVIRONMENTAL FATE ASSESSMENT

I **CMR** - If any of the concern levels are met for any of the parameters and the exposure is classified as an A, B or C, the chemical is promoted (see Appendix 1 for detailed description of the CMR)

Parameter	Concern Level*
Persistence	≥ 4
Bioaccumulation	≥ 7
Acute Toxicity	≥ 7
Other Adverse Effects	≥ 7
Hereditary Mutagenicity	≥ 7
Teratogenicity	≥ 7
Carcinogenicity	≥ 7

III **MOE** - If any of the concern levels are met for any of the parameters and the exposure is classified as an A, B, or C, the chemical is promoted (see Appendix 1 for detailed description of the MOE assessment method)

Parameter	Concern Level*
Persistence	≥10
Bioaccumulation	≥ 7
Acute Lethality	≥ 8
Sub-Lethal Toxicity Non-Mammalian	≥ 6
Sub-Lethal Toxicity Plant	≥10
Sub-Lethal Toxicity Mammalian	≥10
Mutagenicity/Genotoxicity	≥10
Teratogenicity	≥ 4
Carcinogenicity	≥ 6

EXPOSURE ASSESSMENT - Potential Presence in Effluents ≥ C

A - almost "always" present,
- >50% detection and minumum of 5 data points

B - potentially present in Ontario,
- detected in effluent or reported as being discharged
- detected in the natural environment and probable Ontario use/manufacture

C - inferred to be present in a process aqueous discharge and probable Ontario use/manufacture

D - possibly present based on use/manufacturing information only

E - not present - based on analytical data and/or inference from the literature

* CMR and MOE numerical values were assigned to represent equivalent concern levels between the two hazard assessment methods

These substances were excluded from the EMPPL because MISA is designed to address the discharge of toxic chemicals primarily from industrial point sources.

Control mechanisms for pesticides currently exist under the Federal Pesticide Control Products Act and the Ontario Pesticides Act and Regulations. This legislative framework addresses the environmental release of pesticides through the registration, controlled sale and use of these chemicals in Canada and Ontario.

Table 3 lists some of the pesticides and pesticide degradation products identified during the compilation of the primary and secondary groups. A number of these compounds are no longer used in the Province. The presence of many of these chemicals in the environment is a result of their past use and persistence.

Industry is required to report the presence and quantity of pesticides used in their processes. The pesticide industry (manufacturers, formulators and packagers) is being considered for future inclusion under the MISA program as a minor industrial sector.

A number of pharmaceuticals were identified that, if discharged, could represent a hazard (e.g. phenobarbital, progestins). Information on the extent of environmental discharges of such substances from municipal sewage treatment plants is extremely limited. As such, the assessment of pharmaceuticals for the EMPPL requires further review.

TABLE 3: SOME PESTICIDES AND RELATED COMPOUNDS IDENTIFIED IN THE CHEMICAL IDENTIFICATION STAGE

PESTICIDE	FEDERAL REGISTRATION	SCHEDULED IN ONTARIO	
Aldrin	yes	yes	- parent compound
Ametryn	no	no	- parent compound
Atrazine	yes	yes	- parent compound
alpha-BHC	no	no	- isomer
beta-BHC	no	no	- isomer
delta-BHC	no	no	- isomer
gamma-BHC (Lindane)	yes	yes	- parent compound
Captan	yes	yes	- parent compound
Chlordane	yes	yes	- parent compound
2,4-D acid, amine and salts	yes	yes	- parent compound
4,4'-DDD (p,p^1DDD)	no	no	- isomer
4,4'-DDE (p,p^1DDE)	no	no	- metabolite - isomer
4,4'-DDT (p,p^1DDT)	no	no	- isomer
Diazinon	yes	yes	- parent compound
Dichloran	yes	yes	- parent compound
Dieldrin	yes	yes	- parent compound
Endosulfan I	yes	yes	- isomer
Endosulfan II	yes	yes	- isomer
Endosulfan sulphate	no	no	- metabolite
Endrin	yes	yes	- parent compound
Endrin Aldehyde	no	no	- degradation product

TABLE 3 : continued

PESTICIDE	FEDERAL REGISTRATION	SCHEDULED IN ONTARIO	
Heptachlor *	no	yes	- parent compound
Heptachlor epoxide	no	no	- isomer
Malathion	yes	yes	- parent compound
Methoxychlor	yes	yes	- parent compound
Mirex	no	no	- parent compound
Oxychlordane	no	no	- isomer
Parathion ethyl	no	no	- unknown
PCNB (quintozene)	yes	yes	- parent compound
Photomirex	no	no	- degradation product
Strobane	no	no	- parent compound
2,4,5-T *	no	yes	- parent compound
2,4,5-TP (Silvex) *	no	yes	- parent compound
Toxaphene	yes	yes	- parent compound

* Products have been discontinued by registrants as of 1985.

3.2.3 Rationale for Exclusion of Conventional Parameters

Conventional parameters (listed in Table 4) were not evaluated because monitoring for these parameters is mandatory under MISA.

4.0 THE 1987 ONTARIO EFFLUENT MONITORING PRIORITY POLLUTANTS LIST

4.1 CONTENTS OF THE EFFLUENT MONITORING PRIORITY POLLUTANTS LIST

A total of 179 chemicals or groups of chemicals were identified for which effluent monitoring is required. These chemicals, listed in Table 5, constitute the 1987 Effluent Monitoring Priority Pollutants List. In addition, the Table contains the following information:

- the Chemicals Abstract Service (CAS) Registry number;
- whether the chemical was included in the primary (P) or secondary (S) group;
- the criteria employed in assessing the chemical: CMR (I), NRTC (II) or MOE (III);
- the exposure classification: A, B or C;
- whether the substance is cited on the EPA Priority Pollutants List;
- whether it is potentially present in municipal or industrial effluents with a further subdivision into eight industrial sectors. The potential presence in effluents from each sector is denoted by a reference number in the specific sector column; and

TABLE 4: CONVENTIONAL PARAMETERS

1. Chemical Oxygen Demand (COD)
2. Hydrogen Ion (pH)
3. Nitrogen
   - Ammonia plus Ammonium
   - Nitrate
   - Nitrite
   - Total Kjeldahl Nitrogen
4. Organic Carbon
   - Dissolved Organic Carbon (DOC)
   - Total Organic Carbon (TOC)
5. Total Phosphorus
6. Specific Conductance
7. Total Suspended Solids
   Volatile suspended solids
8. Phenolics
9. Sulphide
10. Oil and grease
11. Cyanide

- whether MOE analytical methodologies are currently available (Y = Yes), (P = Possibly), (N = No), where:

N = the MOE laboratory may not have the capability at present to measure a parameter using a validated methodology. However,

  - "no capability" does not mean that the laboratory cannot measure a parameter, but rather that the laboratory cannot currently measure the parameter on a routine basis
  - parameters reported through the use of GC/MS "forensic or characterizational" screens do not represent a routine capability
  - parameters may be measured and reported in MOE reports, but may not have been measured by the instrumentation required for the MISA program

Table 6 lists the concern levels generated using the three assessment methodologies (CMR, NRTC and MOE) for each contaminant identified on the 1987 EMPPL (Table 5). Explanations of the numbers and symbols (*, ?, e, L) used in each assessment methodology are provided in the appropriate subsections of Appendix A.

The EMPPL identifies the chemicals for which there is sufficient concern to warrant monitoring at the present time. The list will be modified through the addition and deletion of chemicals as new information on effects, environmental fate and exposure becomes available.

Table 5 identifies the exposure information that was available during assessment. Not all chemicals on the EMPPL are discharged by every sector. The absence of an entry under a particular sector may reflect a lack of information about that sector rather than indicating that the chemical is not present.

All chemicals on the EMPPL are being considered for monitoring by all sectors, with any exclusions based on additional exposure information or analytical capability limitations being considered on a case-by-case basis.

Validated or routine analytical methods are not available for all chemicals on the EMPPL. The EMPPL assessments may be used to identify those chemicals for which validated or routine methods should be developed on a priority basis.

4.2 LIMITATIONS OF THE ONTARIO EFFLUENT MONITORING PRIORITY POLLUTANTS LIST

There are number of limitations to this EMPPL, in particular:

- limited data base
- uncertainties in assessments.

4.2.1 Limited Data Base

Comprehensive toxicological and environmental fate information is lacking for many chemicals. In developing

Table 5. THE 1987 ONTARIO EFFLUENT MONITORING PRIORITY POLLUTANTS LIST

CHEMICAL NAME	CHEMICAL ABSTRACT NUMBER	TOXICOLOGY ENVIR. FATE	USE RELEASE	EPA PPL	LAB CAP	MUNICIPAL SECTOR	INDUSTRIAL SECTORS	PETROLEUM REFINING	PULP AND PAPER	ORGANIC CHEMICALS	INORGANIC CHEMICALS	Fe/STEEL/ METAL CASTING	ELECTRIC POWER	INDUSTRIAL MINERALS	MINING & REFINING
Abietic acid	514103	P-III	B		P	43	X		3,43						
Acenaphthene	83329	P-III	A	X	Y	4	X	1,6	5	6		2,5			
5-nitro Acenaphthene	602879	S-I	B		Y		X			44					
Acenaphthylene	208968	P-III	A	X	Y	4	X	1,6	5	6		5			
Acridine	260946	P-III	B		N		X					2			
Acrolein	107028	P-I	A	X	Y	4	X			6					
Acrylonitrile	107131	P-I	B	X	Y	4	X			6					
Aluminum	7429905	P-III	B		Y	4	X	1	3	7					
4-Aminoazobenzene	60093	S-I	B		N		X			22,44					
Aniline	62533	P-I	B		N	22,29	X			22,30,44					
Anthracene	120127	P-I	B	X	Y	4	X	1, 6	5	6		2, 5			
Antimony	7440360	P-I	A	X	Y	4	X	1							
Aroclor 1016	12674112	P-III	B	X	Y	4									
Aroclor 1221	11104282	P-III	B	X	Y	4									
Aroclor 1232	11141165	P-III	B	X	Y	4									
Aroclor 1242	53469219	P-III	B	X	Y	4									
Aroclor 1248	12672296	P-III	B	X	Y	4									
Aroclor 1254	11097691	P-III	B	X	Y	4									
Aroclor 1260	11096825	P-III	B	X	Y	4									
Arsenic	7440382	P-I	A	X	Y		X	1	3			5			
Benzaldehyde	100527	P-III	B		N	48	X		3						

Table 5. THE 1987 ONTARIO EFFLUENT MONITORING PRIORITY POLLUTANTS LIST

CHEMICAL NAME	CHEMICAL ABSTRACT NUMBER	TOXICOLOGY ENVIR. FATE	USE RELEASE	EPA PPL	LAB CAP	MUNICIPAL SECTOR	INDUSTRIAL SECTORS	PETROLEUM REFINING	PULP AND PAPER	ORGANIC CHEMICALS	INORGANIC CHEMICALS	Fe/STEEL/ METAL CASTING	ELECTRIC POWER	INDUSTRIAL MINERALS	MINING & REFINING
Benz(a)anthracene	56553	P-I	A	X	Y	4	X	1,6	5	6		2,5			
Benzene	71432	P-I	B	X	Y	4	X	1	3, 5	6, 7		2,5			
Benzeneacetonitrile	140294	P-III	B		N		X					2			
Benzidine	92875	P-I	B	X	N	20,26	X	20				20			14,20
Benzo(b)fluoranthene	205992	P-I	B	X	Y	4	X	1,6	5			2			
Benzo(k)fluoranthene	207089	P-II	A	X	Y	4	X	1	5	6		2,5			
Benzo(g,h,i)perylene	191242	P-III	B	X	Y	4	X	1,6	5	6		2,5			
Benzo(a)pyrene	50328	P-I	B	X	Y	4	X	1,6	5	6		2,5			
Benzyl alcohol	100516	P-I	B		N	22,29	X	22	22	22					22
Beryllium	7440417	P-I	A	X	Y	4	X	1							
Biphenyl	92524	P-I	B		Y	4									
Bromoform	75252	P-I	A	X	Y	4	X			6,7					
Bromomethane	74839	P-I	B	X	Y	4									
4-Bromophenyl phenyl ether	101553	P-I	B	X	Y	4	X	1							
1,3-Butadiene	106990	P-III	B		N		X					2			
Butanal	123728	P-III	B		N		X		3						
Butylbenzylphthalate	85687	P-I	A	X	Y	4	X								
Cadmium	7440439	P-I	B	X	Y	4	X	1	3	7		5			
Camphene	79925	P-III	B		Y		X		3						
Carbon tetrachloride	56235	P-I	B	X	Y	4	X	1	3	6,7					
Chlorinated dibenzofurans *	n/a	P-III	B		Y		X		45						

Table 5. THE 1987 ONTARIO EFFLUENT MONITORING PRIORITY POLLUTANTS LIST

CHEMICAL NAME	CHEMICAL ABSTRACT NUMBER	TOXICOLOGY ENVIR. FATE	USE RELEASE	EPA PPL	LAB CAP	MUNICIPAL SECTOR	INDUSTRIAL SECTORS	PETROLEUM REFINING	PULP AND PAPER	ORGANIC CHEMICALS	INORGANIC CHEMICALS	Fe/STEEL/ METAL CASTING	ELECTRIC POWER	INDUSTRIAL MINERALS	MINING & REFINING
Chlorinated dibenzo-p-dioxins *	n/a	P-III	B		Y		X		45						
Chlorobenzene	108907	P-I	A	X	Y	6	X	1		6,7					
Chlorodehydroabietic acid	57055386	P-III	B		P		X		3,27						
Chlorodibromomethane	124481	P-III	A	X	Y	4	X		3	7		2			
Chloroform	67663	P-I	A	X	Y	4	X	1,6	3,5	6,7		2,5			
Chloromethane	74873	P-I	A	X	Y	4	X								
bis(2-Chloroethoxy)methane	111911	P-III	B		Y	24,53,54	X			14					
bis(2-Chloroethyl)ether	111444	P-I	B		Y	4	X								
bis(2-Chloroisopropyl)ether	108601	P-III	B	X	Y	4	X			47					
bis(Chloromethyl)ether	542881	P-I	B	X	N		X					34			
4-Chloro-3-methylphenol	59507	P-III	B	X	Y	4	X		3						
1-Chloronaphthalene	90131	P-I	B		Y	22									
2-Chloronaphthalene	91587	P-III	B	X	Y	4	X								
o-Chlorophenol	95578	P-I	A	X	Y	4	X								
4-Chlorophenylphenyl ether	7005723	P-I	B	X	Y	4	X								
Chromium	7440473	P-I	B	X	Y	4	X	1	3,5	7		5			
Chrysene	218019	P-II	A	X	Y	4	X	1,6	5	6		2,5			
Cobalt	7440484	P-I	B		Y	4	X	1	3	7					
Copper	7440508	P-I	A	X	Y	4	X	1	3	7		5			
m-Cresol	108394	P-III	B		Y	4,8	X		8			2			
o-Cresol	95487	P-III	B		Y	4,8	X		3,8			2			

Table 5. THE 1987 ONTARIO EFFLUENT MONITORING PRIORITY POLLUTANTS LIST

CHEMICAL NAME	CHEMICAL ABSTRACT NUMBER	TOXICOLOGY ENVIR. FATE	USE RELEASE	EPA PPL	LAB CAP	MUNICIPAL SECTOR	INDUSTRIAL SECTORS	PETROLEUM REFINING	PULP AND PAPER	ORGANIC CHEMICALS	INORGANIC CHEMICALS	Fe/STEEL/ METAL CASTING	ELECTRIC POWER	INDUSTRIAL MINERALS	MINING & REFINING
p-Cresol	106445	P-III	B		Y	4,8	X		8			2			
Dehydroabietic acid	1740198	P-III	B		P		X		3						
Dibenz(a,h)anthracene	53703	P-I	B	X	Y	4	X	1		6		5			
2,6-Di-t-butyl-4-methylphenol	128370	P-III	B		N	8	X		8	8					
Di-n-butylphthalate	84742	P-I	A	X	Y	4	X	1	3	8		2			
1,2-Dichlorobenzene	95501	P-I	A	X	Y	4	X	6		6,7,8					
1,3-Dichlorobenzene	541731	P-I	A	X	Y	4	X	1		6,7,8					
1,4-Dichlorobenzene	106467	P-I	A	X	Y	4	X	6	5	6,7,8		5			
3,3'-Dichlorobenzidine	91941	P-I	B	X	N	23	X			18,44					14
1,1-Dichloroethane	75343	P-I	A	X	Y	4	X	1,6		6,7		5			
1,2-Dichloroethane	107062	P-I	B	X	Y	4	X	1		6,7					
cis-1,2-Dichloroethylene	156592	P-III	B		P		X	1							
trans-1,2-Dichloroethylene	156605	P-I	A		Y	4,12,23,24 32	X	14,32,33		14		12,14			14
1,1-Dichloroethylene	75354	P-I	A	X	Y		X	1		6,7		2			
2,4-Dichlorophenol	120832	P-I	A	X	Y	4	X	1	3	6					
2,6-Dichlorophenol	87650	P-III	B		Y		X			6					
1,2-Dichloropropane	78875	P-I	A	X	Y	4	X	1		6,7					
cis-1,3-Dichloropropylene	10061015	S-III	B		Y		X		43,52,56						
trans-1,3-Dichloropropylene	10061026	P-III	B		Y		X		43,52,56						
bis(2-Ethylhexyl)phthalate	117817	P-I	B	X	Y		X	1	3						

Table 5. THE 1987 ONTARIO EFFLUENT MONITORING PRIORITY POLLUTANTS LIST

CHEMICAL NAME	CHEMICAL ABSTRACT NUMBER	TOXICOLOGY ENVIR. FATE	USE RELEASE	EPA PPL	LAB CAP	MUNICIPAL SECTOR	INDUSTRIAL SECTORS	PETROLEUM REFINING	PULP AND PAPER	ORGANIC CHEMICALS	INORGANIC CHEMICALS	Fe/STEEL/ METAL CASTING	ELECTRIC POWER	INDUSTRIAL MINERALS	MINING & REFINING
Dimethyl disulphide	624920	P-III	B		N	8									
2,4-Dimethylphenol	105679	P-I	A	X	Y	4	X	1	3			2			
4,6-Dinitro-o-cresol	534521	P-I	A	X	Y		X	1							
2,4-Dinitrophenol	51285	P-I	B	X	Y	4	X								
2,4-Dinitrotoluene	121142	P-I	A	X	Y	4	X			6					
2,6-Dinitrotoluene	606202	P-I	A	X	Y	4	X			6					
1,4-Dioxane	123911	S-I	A		N	22	X			18,22,42	18	18			
Diphenylamine	122394	P-II	B		Y		X			22,44	22				
Diphenyl ether	101848	P-III	B		Y	4	X			8					
Ethylene dibromide	106934	P-I	B		Y	22	X	20							
Ethylene thiourea	96457	S-I	C		N		X			44					
Eugenol	97530	P-III	B		N		X		3						
Fluoranthene	206440	P-II	B	X	Y	4	X	1,6	3,5	6		2, 5			
Fluorene	86737	P-III	A	X	Y	4	X	6	5	6		2, 5			
Formaldehyde	50000	P-I	B		N		X			38,39,44					
Hexachlorobenzene	118741	P-I	B	X	Y	4, 6	X	1,6	3	6, 7					
Hexachlorobutadiene	87683	P-I	A	X	Y	4, 6	X	1, 6		6, 7					
Hexachlorocyclopentadiene	77474	P-I	B	X	Y	4	X		3						
Hexachloroethane	67721	P-I	A	X	Y	4, 6	X	1, 6		6, 7					
Hydrazine	302012	S-I	B		N		X	44	18,44	44	44	44	44	44	18,44
2-Hydroxybiphenyl	90437	P-III	B		N	8									

Table 5. THE 1987 ONTARIO EFFLUENT MONITORING PRIORITY POLLUTANTS LIST

CHEMICAL NAME	CHEMICAL ABSTRACT NUMBER	TOXICOLOGY ENVIR. FATE	USE RELEASE	EPA PPL	LAB CAP	MUNICIPAL SECTOR	INDUSTRIAL SECTORS	PETROLEUM REFINING	PULP AND PAPER	ORGANIC CHEMICALS	INORGANIC CHEMICALS	Fe/STEEL/ METAL CASTING	ELECTRIC POWER	INDUSTRIAL MINERALS	MINING & REFINING
4-Hydroxybiphenyl	92693	P-III	B		N	8									
Indeno(1,2,3-cd)pyrene	193395	P-III	A	X	Y	4	X	1	5	6		2, 5			
Indole	120729	P-III	B		Y	8,43,48	X					2			
Isopimaric acid	5835267	P-III	B		P		X		3						
Lead	7439921	P-I	B	X	Y	4	X	1	3, 5	7		5			
Levopimaric acid	79549	P-III	B		P		X		3						
Limonene	138863	P-III	B		N		X		3	8					
Mercaptobenzothiazole	149304	P-III	B		N	8	X		8						
Mercury	7439976	P-I	B	X	Y	4	X	1	3	7					
Methylene chloride	75092	P-I	B	X	Y	4	X		3	6					
Methyl ethyl ketone	78933	P-III	B		N		X		3						
n-Methylformamide	123397	P-III	B		N		X		3						
1-Methylnaphthalene	90120	P-III	B		Y	8	X		8	8	50				
2-Methylnaphthalene	91576	P-III	B		Y	8	X		8	8	50	2			
Methyl styrene	25013154	P-III	B		N		X			8					
Molybdenum	7439987	P-III	B		Y	4	X	1	3						
Naphthalene	91203	P-I	A	X	Y	4	X	1, 6	3, 5	6, 8		2, 5			
Neoabietic acid	471772	P-III	B		P		X		3						
Nickel	7440020	P-I	B	X	Y	4	X	1	3, 5	7		5			
1-Nitronaphthalene	86577	P-III	B		N		X			8					
2-Nitronaphthalene	581895	P-III	B		N		X			8					

Table 5. THE 1987 ONTARIO EFFLUENT MONITORING PRIORITY POLLUTANTS LIST

CHEMICAL NAME	CHEMICAL ABSTRACT NUMBER	TOXICOLOGY ENVIR. FATE	USE RELEASE	EPA PPL	LAB CAP	MUNICIPAL SECTOR	INDUSTRIAL SECTORS	PETROLEUM REFINING	PULP AND PAPER	ORGANIC CHEMICALS	INORGANIC CHEMICALS	Fe/STEEL/ METAL CASTING	ELECTRIC POWER	INDUSTRIAL MINERALS	MINING & REFINING
4-Nitrophenol	100027	P-I	A	X	Y	4	X	1	3						
n-Nitrosodimethylamine	62759	P-I	B	X	N	4									
n-Nitrosodi-n-propylamine	621647	P-III	B	X	Y	4	X								
n-Nitrosodiphenylamine	86306	P-I	B	X	Y	4	X		3						
Octachlorostyrene	29082744	P-I	B		Y	6	X	1,6		6, 7					
Oleic acid	112801	P-III	B		P		X		3						
Pentachlorobenzene	608935	P-III	B		Y	6	X	1		6, 7					
Pentachlorophenol	87865	P-I	B	X	Y	4	X	1, 6	3	6					
Perylene	198550	P-III	B		Y		X					2			
Phenanthrene	85018	P-III	A	X	Y		X					2			
Phenol	108952	P-I	B	X	Y	4	X	1, 6	3, 5	6		2, 5			
Pimaric acid	127275	P-III	B		P		X		3						
Pyrene	129000	P-II	A	X	Y	4	X	1, 6	5	6		2, 5			
Selenium	7782492	P-I	B	X	Y	4	X	1							
Silver	7440224	P-I	A	X	Y	4	X	1							
Styrene	100425	P-I	B		Y	4	X		3	6		2, 5			
Tetrachloroacetone	31422614	P-III	B		N		X		3						
1,1,3,3-Tetrachloroacetone	632213	P-III	B		N		X		46						
1,2,3,4-Tetrachlorobenzene	634662	P-III	B		Y		X	1		6, 7, 8					
1,2,3,5-Tetrachlorobenzene	634902	P-III	B		Y		X			6,7,8					
1,2,4,5-Tetrachlorobenzene	95943	P-III	B		Y		X	6		6, 7, 8					

Table 5. THE 1987 ONTARIO EFFLUENT MONITORING PRIORITY POLLUTANTS LIST

CHEMICAL NAME	CHEMICAL ABSTRACT NUMBER	TOXICOLOGY ENVIR. FATE	USE RELEASE	EPA PPL	LAB CAP	MUNICIPAL SECTOR	INDUSTRIAL SECTORS	PETROLEUM REFINING	PULP AND PAPER	ORGANIC CHEMICALS	INORGANIC CHEMICALS	Fe/STEEL/ METAL CASTING	ELECTRIC POWER	INDUSTRIAL MINERALS	MINING & REFINING
2,3,7,8-Tetrachlorodibenzo-p-dioxin	1746016	P-III	B	X	Y	4									
1,1,2,2-Tetrachloroethane	79345	P-I	A	X	Y	6,12,23, 24,25,26,28 31,36	X	14,33	27,32	14,43		14	34		14
Tetrachloroethylene	127184	P-I	A	X	Y	4, 6	X	1	3, 5	6, 7					
Tetrachloroguaiacol	2539175	P-III	B		P		X		3						
2,3,4,5-Tetrachlorophenol	4901513	P-III	B		Y		X	1	3	6					
2,3,4,6-Tetrachlorophenol	58902	P-III	B		Y		X	1		6					
2,3,5,6-Tetrachlorophenol	935955	P-III	B		Y		X		3	6					
Tetraethyl lead	78002	P-III	B		Y		X			38,50					
Thallium	7440280	P-I	A	X	Y	4	X	1							
Thiourea	62566	S-I	B		P		X		18	18,44			18		18
Toluene	108883	P-I	B	X	Y	4	X	1	3, 5	6, 7		2, 5			
Tributyl phosphate	126738	P-III	B		N		X		3	42,43,48	48	48			
1,1,3-Trichloroacetone	921039	P-III	B		N		X		46						
1,2,3-Trichlorobenzene	87616	P-I	B		Y		X			6, 7, 8					
1,2,4-Trichlorobenzene	120821	P-III	A	X	Y	4	X	1		6, 7, 8					
1,1,2-Trichloroethane	79005	P-I	A	X	Y	4	X			6, 7					
Trichloroethylene	79016	P-I	B	X	Y	4	X	1	3	6, 7		2			
Trichlorofluoromethane	75694	P-III	A		Y	4	X	1							
Trichloroguaiacol	61966367	P-III	B		P		X		3						

Table 5. THE 1987 ONTARIO EFFLUENT MONITORING PRIORITY POLLUTANTS LIST

CHEMICAL NAME	CHEMICAL ABSTRACT NUMBER	TOXICOLOGY ENVIR. FATE	USE RELEASE	EPA PPL	LAB CAP	MUNICIPAL SECTOR	INDUSTRIAL SECTORS	PETROLEUM REFINING	PULP AND PAPER	ORGANIC CHEMICALS	INORGANIC CHEMICALS	Fe/STEEL/ METAL CASTING	ELECTRIC POWER	INDUSTRIAL MINERALS	MINING & REFINING
2,3,4-Trichlorophenol	15950660	P-III	B		Y		X		3						
2,3,5-Trichlorophenol	933788	P-III	B		Y		X			6					
2,4,5-Trichlorophenol	95954	P-I	B		Y		X		3,14,20,22	6,20,22	22				
2,4,6-Trichlorophenol	88062	P-I	A	X	Y		X		3	6					
2,4,5-Trichlorotoluene	6639301	P-III	B		Y		X			7					
Triethyl lead	n/a	P-III	B		Y		X			50					
Trimethylbenzenes	25551137	P-III	B		N		X			21					
Trimethylnaphthalenes	28652779	P-III	B		N		X			8		2			
Vanadium	7440622	P-III	B		Y		X	1							
Vinyl chloride	75014	P-I	B	X	Y	4	X	1, 6							
o-Xylene	95476	P-I	A		Y	4	X	1, 6	3, 5			2,5			
m-Xylene	108383	P-I	A		Y	4	X	1, 6	3, 5			2,5			
p-Xylene	106423	P-I	A		Y	4	X	1, 6	3, 5			2,5			
Zinc	7440666	P-I	A	X	Y	4	X	1	3, 5	7		5			

*Represents tetra-, penta-, hexa-, hepta-, and octa- congeners.

TABLE 6. HAZARD ASSESSMENTS BY CMR, NRTC AND MOE - 1987

CHEMICAL NAME	CHEMICAL ABSTRACT NUMBER	Toxicol. Env. Fate	C.M.R.												NRTC	M.O.E.								
			I.Acute TOXICITY			II.	III	IV.	V.	VI. Bio accumul		VII. Other Adverse Eff				Enviro.			Toxicity Sub-Lethal					
			ORAL	DERML	AQUAT	CARCIN	HMUTAT	TERAT	PERSIS	BCF	LOG P	TERS	AQUAT	PLANT	GROUP	PERSIST	BIOACCUM	ACUTE	NONMAM	PLANT	MAMMAL	TERAT	GEN/MUT	CARCIN
Abietic acid	514103	P-III														•	10e	8	•	•	•	•	•	•
Acenaphthene	83329	P-III														•	4	8	0	6	•	•	2L	•
5-nitro Acenaphthene	602879	S-I	•	•	•	7	•	•	•	•	•	•	•	•										
Acenaphthylene	208968	P-III														•	7e	•	•	•	•	•	2L	•
Acridine	260946	P-III														•	4	6L	4L	•	•	•	2	•
Acrolein	107028	P-I	•	•	7	•	•	•	•	1	•	1	7	•										
Acrylonitrile	107131	P-I	3	•	3	7	2	3	•	•	•	3	•	•										
Aluminum	7429905	P-III														10	7	8?	6?	6?	6?	2	0?	•
4-Aminoazobenzene	60093	S-I	•	•	•	7	•	•	•	•	•	•	•	•										
Aniline	62533	P-I	2	1	2	3	•	•	•	•	•	3	3	•										
Anthracene	120127	P-I	•	•	•	•	•	•	1-T	3	2	•	•	•										
Antimony	7440360	P-I	2	•	3	•	•	•	N-A	7	•	3	•	2										
Aroclor 1016	12674112	P-III														10e	10	8	6L	2	•	•	0e	8e
Aroclor 1221	11104282	P-III														10e	4e	6	6	•	•	8	4L	8e
Aroclor 1232	11141165	P-III														10e	4e	8	6	•	•	•	0e	8e
Aroclor 1242	53469219	P-III														10e	10	10	6	•	•	8	0e	8e

TABLE 6. HAZARD ASSESSMENTS BY CMR, NRTC AND MOE - 1987

CHEMICAL NAME	CHEMICAL ABSTRACT NUMBER	Toxicol. Env. Fate	C.M.R.												NRTC	M.O.E.								
			I.Acute TOXICITY			II.	III	IV.	V.	VI. Bio accumul		VII. Other Adverse Eff				Enviro.			Toxicity Sub-Lethal					
			ORAL	DERML	AQUAT	CARCIN	HMUTAT	TERAT	PERSIS	BCF	LOGP	TERS	AQUAT	PLANT	GROUP	PERSIST	BIOACCUM	ACUTE	NONMAM	PLANT	MAMMAL	TERAT	GEN/MUT	CARCIN
Aroclor 1248	12672296	P-III														10e	10	10	10	*	*	8	0e	8e
Aroclor 1254	11097691	P-III														10e	10	10	10	*	2L	6	6	8L
Aroclor 1260	11096825	P-III														10e	10	8	8	*	*	6L	0e	8
Arsenic	7440382	P-I	3	*	3	7	*	3	N-A	2	*	3	2	2										
Benzaldehyde	100527	P-III														0?	0	6	*	*	*	*	*	*
Benz(a)anthracene	56553	P-I	*	*	*	7	*	*	*	*	*	*	*	*										
Benzene	71432	P-I	1	*	2	7	*	*	*	0	*	3	2	3										
Benzeneacetonitrile	140294	P-III														*	*	6	*	*	0	*	*	*
Benzidine	92875	P-I	2	*	0	7	4	*	*	*	0	3	*	*										
Benzo(b)fluoranthene	205992	P-I	*	*	*	3	*	*	*	*	*	*	*	*										
Benzo(k)fluoranthene	207089	P-II													1									
Benzo(g,h,i)perylene	191242	P-III														10e	10	*	*	*	*	*	4L	2L
Benzo(a)pyrene	50328	P-I	*	*	*	7	*	3	*	*	*	*	7	3										
Benzyl alcohol	100516	P-I	*	*	3	*	*	*	*	*	0	*	*	*										
Beryllium	7440417	P-I	2	*	7	2	*	*	N-A	*	*	3	*	*										
Biphenyl	92524	P-I	1	1	3	*	*	*	*	1	*	2	*	*										

TABLE 6. HAZARD ASSESSMENTS BY CMR, NRTC AND MOE - 1987

CHEMICAL NAME	CHEMICAL ABSTRACT NUMBER	Toxicol. Env. Fate	C.M.R.												NRTC	M.O.E.								
			I.Acute TOXICITY			II.	III	IV.	V.	VI. Bio accumul		VII. Other Adverse Eff				Enviro.			Toxicity Sub-Lethal					
			ORAL	DERML	AQUAT	CARCIN	HMUTAT	TERAT	PERSIS	BCF	LOG P	TERS	AQUAT	PLANT	GROUP	PERSIST	BIOACCUM	ACUTE	NONMAM	PLANT	MAMMAL	TERAT	GEN/MUT	CARCIN
Bromoform	75252	P-I	1	*	3	1	*	*	*	*	*	2	2	*										
Bromomethane	74839	P-I	*	*	2	3	7	*	*	*	0	3	*	*										
4-Bromophenyl phenyl ether	101553	P-I	*	*	3	*	*	*	*	*	3	*	*	*										
1,3-Butadiene	106990	P-III														*	0	4	*	*	*	2	*	10
Butanal	123728	P-III														*	0	4	*	*	*	*	8L	*
Butylbenzylphthalate	85687	P-I	1	*	3	*	*	*	*	*	*	3	3	3										
Cadmium	7440439	P-I	*	*	*	*	*	*	*	*	*	*	7	*										
Camphene	79925	P-III														*	*	61	0	*	*	*	*	*
Carbon tetrachloride	56235	P-I	1	*	2	7	2	*	*	*	*	1	1	0										
Chlorinated dibenzofurans, tetra-	n/a	P-III														*	7	10	6L	*	*	10	*	*
Chlorinated dibenzofurans, penta-	n/a	P-III														*	7e	10	*	*	*	*	*	*
Chlorinated dibenzofurans, hexa-	n/a	P-III														*	7e	10	*	*	*	*	*	*
Chlorinated dibenzofurans, hepta-	n/a	P-III														*	7e	*	*	*	*	*	*	*
Chlorinated dibenzofuran, octa-	n/a	P-III														*	7e	*	*	*	*	*	*	*
Chlorinated dibenzo-p-dioxins, tetra-	n/a	P-III														10	10	10	10	0L	10	10	8L	8
Chlorinated dibenzo-p-dioxins, penta-	n/a	P-III														10e	10e	10	*	*	*	*	*	*

TABLE 6. HAZARD ASSESSMENTS BY CMR, NRTC AND MOE - 1987

CHEMICAL NAME	CHEMICAL ABSTRACT NUMBER	Toxicol. Env. Fate	C.M.R. I. Acute TOXICITY			C.M.R. II.	C.M.R. III	C.M.R. IV.	C.M.R. V.	C.M.R. VI. Bio accumul		C.M.R. VII. Other Adverse Eff			NRTC	M.O.E. Enviro.		M.O.E.	M.O.E. Toxicity Sub-Lethal			M.O.E.		
			ORAL	DERML	AQUAT	CARCIN	MUTAT	TERAT	PERSIS	BCF	LOG P	TERS	AQUAT	PLANT	GROUP	PERSIST	BIOACCUM	ACUTE	NONMAM	PLANT	MAMMAL	TERAT	GEN/MUT	CARCIN
Chlorinated dibenzo-p-dioxins, hexa-	34465468	P-III														10e	10e	10	*	*	*	10	*	8
Chlorinated dibenzo-p-dioxins, hepta-	n/a	P-III														10e	10e	8L	*	*	*	*	*	*
Chlorinated dibenzo-p-dioxin, octa-	326887	P-III														10e	10e	21	*	*	*	*	*	*
Chlorobenzene	108907	P-I	*	*	7	3	*	*	*	*	*	1	7	1										
Chlorodehydroabietic acid	57055386	P-III														*	*	8	*	*	*	*	*	*
Chlorodibromomethane	124481	P-III														*	4e	4?	*	*	0	4L	10	*
Chloroform	67663	P-I	2	*	2	7	*	*	*	0	*	3	*	*										
Chloromethane	74873	P-I	*	*	1	3	2	7	*	*	0	3	*	*										
bis(2-Chloroethoxy)methane	111911	P-III														10e	0e	4	*	*	*	*	*	*
bis(2-Chloroethyl)ether	111444	P-I	2	2	1	3	*	*	*	*	*	3	*	*										
bis(2-Chloroisopropyl)ether	108601	P-I	*	*	*	3	*	*	*	*	*	2	*	*										
bis(Chloromethyl)ether	542881	P-I	2	2	*	3	*	*	*	*	*	*	*	*										
4-Chloro-3-methylphenol	59507	P-III														*	4	10	2	2	*	*	*	*
1-Chloronaphthalene	90131	P-I	1	*	3	*	*	*	*	*	1	*	*	*										
2-Chloronaphthalene	91587	P-III														*	7	6	*	*	*	*	*	*
o-Chlorophenol	95578	P-I	2	*	3	*	*	*	0-T	0	0	*	*	*										

TABLE 6. HAZARD ASSESSMENTS BY CMR, NRTC AND MOE - 1987

CHEMICAL NAME	CHEMICAL ABSTRACT NUMBER	Toxicol. Env. Fate	C.M.R.												NRTC	M.O.E.								
			I. Acute TOXICITY			II.	III	IV.	V.	VI. Bio accumul		VII. Other Adverse Eff				Enviro.			Toxicity Sub-Lethal					
			ORAL	DERMAL	AQUAT	CARCIN	HMUTAT	TERAT	PERSIS	BCF	LOG P	TERS	AQUAT	PLANT	GROUP	PERSIST	BIOACCUM	ACUTE	NONMAM	PLANT	MAMMAL	TERAT	GEN/MUT	CARCIN
4-Chlorophenylphenyl ether	7005723	P-I	*	*	7	*	*	*	*	*	2	*	*	*										
Chromium	7440473	P-I	2	*	3	2	*	*	N-A	*	*	1	2	2										
Chrysene	218019	P-II													1									
Cobalt	7440484	P-I	2	*	*	*	*	*	N-A	2	*	3	*	*										
Copper	7440508	P-I	3	*	7	*	*	*	N-A	*	*	3	*	3										
m-Cresol	108394	P-III														0L	0	6I	2L	2L	*	0L	8L	*
o-Cresol	95487	P-III														0	0	6	2L	*	0L	*	*	4L
p-Cresol	106445	P-III														0L	0	6	0	*	*	*	*	2L
Dehydroabietic acid	1740198	P-III														4	4	8	2	*	*	*	*	*
Dibenz(a,h)anthracene	53703	P-I	*	*	*	7	*	*	*	*	7	*	*	*										
2,6-Di-t-butyl-4-methylphenol	128370	P-III														*	7	2	6L	*	*	2	10	10L
Di-n-butylphthalate	84742	P-I	*	7	7	*	*	3	*	*	*	3	*	*										
1,2-Dichlorobenzene	95501	P-I	*	*	3	*	*	*	*	*	*	2	2	*										
1,3-Dichlorobenzene	541731	P-I	*	*	3	*	*	*	*	*	*	*	2	*										
1,4-Dichlorobenzene	106467	P-I	*	*	3	*	*	*	*	*	*	3	1	*										
3,3'-Dichlorobenzidine	91941	P-I	*	*	*	7	*	*	*	1	*	*	*	*										

TABLE 6. HAZARD ASSESSMENTS BY CMR, NRTC AND MOE - 1987

CHEMICAL NAME	CHEMICAL ABSTRACT NUMBER	Toxicol. Env. Fate	C.M.R.												NRTC	M.O.E.								
			I.Acute TOXICITY			II.	III	IV.	V.	VI. Bio accumul		VII. Other Adverse Eff				Enviro.			Toxicity Sub-Lethal					
			ORAL	DERMAL	AQUAT	CARCIN	MUTAT	TERAT	PERSIS	BCF	LOG P	TERS	AQUAT	PLANT	GROUP	PERSIST	BIOACCUM	ACUTE	NONMAMM	PLANT	MAMMAL	TERAT	GEN/MUT	CARCIN
1,1-Dichloroethane	75343	P-I	2	1	2	7	*	*	*	0	*	3	*	*										
1,2-Dichloroethane	107062	P-I	2	1	2	7	*	*	*	0	*	3	*	*										
cis-1,2-Dichloroethylene	156592	P-III														0	0	0L	*	*	0L	*	10L	*
trans-1,2-Dichloroethylene	156605	P-I	1	*	1	*	*	*	*	0	*	3	*	*										
1,1-Dichloroethylene	75354	P-I	1	*	2	2	*	*	*	*	*	3	1	0										
2,4-Dichlorophenol	120832	P-I	*	*	3	*	*	*	*	*	0	*	3	1										
2,6-Dichlorophenol	87650	P-III														0e	4	6	*	*	*	*	*	*
1,2-Dichloropropane	78875	P-I	1	0	*	7	*	*	*	*	*	*	2	*										
cis-1,3-Dichloropropylene	10061015	S-III														4I	0e	4	2L	10L	4	*	10	2L
trans-1,3-Dichloropropylene	10061026	P-III														4	0e	6I	2	10L	*	*	10	*
bis(2-Ethylhexyl)phthalate	117817	P-I	0	0	*	7	*	7	*	7	7	3	7	*										
Dimethyldisulfide	624920	P-III														*	0	8	*	*	*	*	*	*
2,4-Dimethylphenol	105679	P-I	*	*	3	*	*	*	*	*	*	*	2	0										
4,6-Dinitro-o-cresol	534521	P-I	3	*	7	1	*	*	*	*	*	3	*	1										
2,4-Dinitrophenol	51285	P-I	3	*	3	*	*	*	*	*	*	3	3	*										
2,4-Dinitrotoluene	121142	P-I	2	*	2	7	*	*	*	0	0	3	7	2										

TABLE 6. HAZARD ASSESSMENTS BY CMR, NRTC AND MOE - 1987

CHEMICAL NAME	CHEMICAL ABSTRACT NUMBER	Toxicol. Env. Fate	C.M.R.												NRTC	M.O.E.								
			I.Acute TOXICITY			II.	III	IV.	V.	VI. Bio accumul		VII. Other Adverse Eff				Enviro.			Toxicity Sub-Lethal					
			ORAL	DERMAL	AQUAT	CARCIN	HMUTAT	TERAT	PERSIS	BCF	LOG P	TERS	AQUAT	PLANT	GROUP	PERSIST	BIOACCUM	ACUTE	NONMAM	PLANT	MAMMAL	TERAT	GEN/MUT	CARCIN
2,6-Dinitrotoluene	606202	P-I	2	*	2	1	*	*	*	*	0	3	*	1										
1,4-Dioxane	123911	S-I	1	*	*	7	*	*	*	*	*	7	*	*										
Diphenylamine	122394	P-II													2									
Diphenyl ether	101848	P-III														*	4	81	*	*	*	*	*	*
Ethylene dibromide	106934	P-I	2	2	2	7	2	*	*	*	*	3	*	*										
Ethylene thiourea	96457	S-I	*	*	*	7	*	7	*	*	*	2	*	*										
Eugenol	97530	P-III														*	*	6	*	*	0	*	10	*
Fluoranthene	206440	P-II													1									
Fluorene	86737	P-III														4L	7	*	*	*	*	*	0	*
Formaldehyde	50000	P-I	2	2	3	*	*	*	*	*	*	2	*	*										
Hexachlorobenzene	118741	P-I	*	*	3	7	*	*	*	*	*	3	*	*										
Hexachlorobutadiene	87683	P-I	3	*	7	3	*	*	*	2	2	2	7	*										
Hexachlorocyclopentadiene	77474	P-I	2	2	7	*	*	*	0-W	0	*	2	7	*										
Hexachloroethane	67721	P-I	1	*	*	3	*	*	0-W	*	0	3	*	*										
Hydrazine	302012	S-I	2	3	3	7	*	7	*	*	*	*	3	*										
2-Hydroxybiphenyl	90437	P-III														*	*	2	*	*	2	2	10	*

TABLE 6. HAZARD ASSESSMENTS BY CMR, NRTC AND MOE - 1987

CHEMICAL NAME	CHEMICAL ABSTRACT NUMBER	Toxicol. Env. Fate	C.M.R.												NRTC	M.O.E.								
			I.Acute TOXICITY			II.	III	IV.	V.	VI. Bio accumul		VII. Other Adverse Eff				Enviro.			Toxicity Sub-Lethal					
			ORAL	DERMAL	AQUAT	CARCIN	NMUTAT	TERAT	PERSIS	BCF	LOG P	TERS	AQUAT	PLANT	GROUP	PERSIST	BIOACCUM	ACUTE	NONMAM	PLANT	MAMMAL	TERAT	GEN/MUT	CARCIN
4-Hydroxybiphenyl	92693	P-III														*	4	6L	*	*	*	*	*	*
Indeno(1,2,3-cd)pyrene	193395	P-III														10e	10e	*	*	*	*	*	2L	10
Indole	120729	P-III														*	4	2	0	*	*	*	*	6L
Isopimaric acid	5835267	P-III														*	*	8	*	*	*	*	*	*
Lead	7439921	P-I	2	*	7	7	*	3	N-A	*	*	7	*	*										
Levopimaric acid	79549	P-III														*	*	8	*	*	*	*	*	*
Limonene	138863	P-III														*	*	47	*	*	*	2L	*	*
Mercaptobenzothiazole	149304	P-III														*	*	4	*	*	*	2L	*	*
Mercury	7439976	P-I	2	*	7	*	*	7	N-A	7	*	3	*	*										
Methylene chloride	75092	P-I	1	*	2	2	*	*	*	*	*	2	*	0										
Methyl ethyl ketone	78933	P-III														0	0	2	*	*	0L	2	*	*
n-Methylformamide	123397	P-III														*	*	2	*	*	*	6	*	*
1-Methylnaphthalene	90120	P-III														*	4	6	*	4	*	*	*	*
2-Methylnaphthalene	91576	P-III														*	7	6	*	4	*	*	*	*
Methyl styrene	25011354	P-III														*	4	4	*	*	*	2L	10	*
Molybdenum	7439987	P-III														10	41	4L	*	*	*	*	10L	*

TABLE 6. HAZARD ASSESSMENTS BY CMR, NRTC AND MOE - 1987

CHEMICAL NAME	CHEMICAL ABSTRACT NUMBER	Toxicol. Env. Fate	C.M.R.												NRTC	M.O.E.								
			I.Acute TOXICITY			II.	III	IV.	V.	VI. Bio accumul		VII. Other Adverse Eff				Enviro.			Toxicity Sub-Lethal					
			ORAL	DERMAL	AQUAT	CARCIN	MUTAT	TERAT	PERSIS	BCF	LOG P	TERS	AQUAT	PLANT	GROUP	PERSIST	BIOACCUM	ACUTE	NONMAM	PLANT	MAMMAL	TERAT	GEN/MUT	CARCIN
Naphthalene	91203	P-I	1	1	3	*	*	*	*	*	0	3	*	*										
Neoabietic acid	471772	P-III														*	*	6	*	*	*	*	2L	*
Nickel	7440020	P-I	3	*	3	2	*	*	N-A	7	*	3	7	*										
1-Nitronaphthalene	86577	P-III														*	4	6	2	*	*	*	*	0L
2-Nitronaphthalene	581895	P-III														*	*	*	*	*	*	*	10	10
4-Nitrophenol	100027	P-I	2	*	3	2	*	*	*	0	*	*	2	1										
n-Nitrosodimethylamine	62759	P-I	3	*	*	7	*	*	*	*	*	3	*	*										
n-Nitrosodi-n-propylamine	621647	P-III														*	0	4	*	*	*	*	10	10
n-Nitrosodiphenylamine	86306	P-I	1	*	*	3	*	*	*	*	*	2	*	*										
Octachlorostyrene	29082744	P-I	*	*	*	*	*	*	*	7	7	2	*	*										
Oleic acid	112801	P-III														*	*	2	*	*	*	*	10	0L
Pentachlorobenzene	608935	P-III														10	10	8	6L	*	*	4	*	*
Pentachlorophenol	87865	P-I	3	3	7	*	*	*	2-S	3	3	3	7	*										
Perylene	198550	P-III														10e	10e	*	*	*	*	*	10	*
Phenanthrene	85018	P-III														*	7	8	*	*	*	*	10	10L
Phenol	108952	P-I	1	1	3	*	*	*	*	0	0	2	2	0										

TABLE 6. HAZARD ASSESSMENTS BY CMR, NRTC AND MOE - 1987

			C.M.R.												NRTC	M.O.E.								
			I.Acute TOXICITY			II.	III	IV.	V.	VI. Bio accumul		VII. Other Adverse Eff				Enviro.			Toxicity Sub-Lethal					
CHEMICAL NAME	CHEMICAL ABSTRACT NUMBER	Toxicol. Env. Fate	ORAL	DERMAL	AQUAT	CARCIN	HMUTAT	TERAT	PERSIS	BCF	LOG P	TERS	AQUAT	PLANT	GROUP	PERSIST	BIOACCUM	ACUTE	NONMAM	PLANT	MAMMAL	TERAT	GEN/MUT	CARCIN
Pimaric acid	127275	P-III														*	*	8	*	*	*	*	*	*
Pyrene	129000	P-II													1									
Selenium	7782492	P-I	2	*	2	7	*	7	N-A	*	*	3	*	*										
Silver	7440224	P-I	3	*	7	*	*	*	N-A	*	*	3	*	*										
Styrene	100425	P-I	2	*	2	3	*	*	*	*	0	2	*	*										
Tetrachloroacetone	31422614	P-III														*	*	*	*	*	*	4	*	*
1,1,3,3-Tetrachloroacetone	632213	P-III														*	*	6	*	*	*	6l	*	*
1,2,3,4-Tetrachlorobenzene	634662	P-III														*	7	8	*	*	*	2	*	*
1,2,3,5-Tetrachlorobenzene	634902	P-III														*	7	8	2L	4	2L	2L	*	*
1,2,4,5-Tetrachlorobenzene	95943	P-III														*	7	8	2	2	6	0	8	*
2,3,7,8-Tetrachlorodibenzo-p-dioxin	1746016	P-III														10	10	10	10	0L	10	10	8L	8
1,1,2,2-Tetrachloroethane	79345	P-I	2	1	3	3	*	*	4-A	0	*	3	*	*										
Tetrachloroethylene	127184	P-I	*	*	2	7	*	*	*	0	*	2	*	*										
Tetrachloroguaiacol	2539175	P-III														*	7	8	*	*	*	*	*	*
2,3,4,5-Tetrachlorophenol	4901513	P-III														*	7	8	*	*	*	*	*	*
2,3,4,6-Tetrachlorophenol	58902	P-III														0L	4	8	*	*	*	2	*	10L

TABLE 6. HAZARD ASSESSMENTS BY CMR, NRTC AND MOE - 1987

CHEMICAL NAME	CHEMICAL ABSTRACT NUMBER	Toxicol. Env. Fate	C.M.R.												NRTC	M.O.E.								
			I.Acute TOXICITY			II.	III	IV.	V.	VI. Bio accumul		VII. Other Adverse Eff				Enviro.			Toxicity Sub-Lethal					
			ORAL	DERML	AQUAT	CARCIN	HMUTAT	TERAT	PERSIS	BCF	LOG P	TERS	AQUAT	PLANT	GROUP	PERSIST	BIOACCUM	ACUTE	NONMAM	PLANT	MAMMAL	TERAT	GEN/MUT	CARCIN
2,3,5,6-Tetrachlorophenol	935955	P-III														*	4L	8	*	*	*	*	*	*
Tetraethyl lead	78002	P-III														10	7	8	6	6	8!	6	8L	10L
Thallium	7440280	P-I	3	*	3	*	*	*	N A	*	*	3	*	*										
Thiourea	62566	S-I	2	*	*	7	*	*	*	*	*	*	*	*										
Toluene	108883	P-I	1	*	3	*	*	*	*	*	*	2	*	*										
Tributyl phosphate	126738	P-III														*	4	6	*	*	*	*	*	*
1,1,3-Trichloroacetone	921039	P-III														*	*	6	*	*	*	*	*	*
1,2,3-Trichlorobenzene	87616	P-I	*	*	7	*	*	*	*	2	*	2	7	2										
1,2,4 Trichlorobenzene	120821	P-III														4L	7	6	4	4L	2	0L	2L	0
1,1,2-Trichloroethane	79005	P-I	1	0	2	7	*	*	*	*	*	2	1	0										
Trichloroethylene	79016	P-I	1	*	2	7	*	*	*	0	0	3	*	*										
Trichlorofluoromethane	75694	P-III														10	4	0	*	*	0	0	8L	0
Trichloroguaiacol	61966367	P-III														*	*	8	*	*	*	*	*	*
2,3,4-Trichlorophenol	15950660	P-III														*	4e	6L	*	*	*	*	*	*
2,3,5-Trichlorophenol	933788	P-III														*	7!	8	*	*	*	*	*	*
2,4,5-Trichlorophenol	95954	P-I	1	*	7	*	*	*	*	*	0	3	2	*										

TABLE 6. HAZARD ASSESSMENTS BY CMR, NRTC AND MOE - 1987

CHEMICAL NAME	CHEMICAL ABSTRACT NUMBER	Toxicol. Env. Fate	C.M.R. I.Acute TOXICITY			II.	III	IV.	V.	VI. Bio accumul		VII. Other Adverse Eff			NRTC	M.O.E. Enviro.			Toxicity Sub-Lethal					
			ORAL	DERMAL	AQUAT	CARCIN	HMUTAT	TERAT	PERSIS	BCF	LOG P	TERS	AQUAT	PLANT	GROUP	PERSIST	BIOACCUM	ACUTE	NONMAM	PLANT	MAMMAL	TERAT	GEN/MUT	CARCIN
2,4,6-Trichlorophenol	88062	P-I	*	*	7	7	2	*	*	*	*	3	1	*										
2,4,5-Trichlorotoluene	6639301	P-III														*	7	8	2	*	*	*	*	*
Triethyl lead	n/a	P-III														10L	*	6IL	*	*	*	*	*	*
Trimethylbenzenes	25551137	P-III														*	*	6I	*	*	*	*	*	*
Trimethylnaphthalenes	28652779	P-III														*	*	6	*	*	*	*	*	*
Vanadium	7440622	P-III														10L	7L	*	*	*	*	*	*	*
Vinyl chloride	75014	P-I	2	*	0	2	*	*	*	*	*	2	*	*										
o-Xylene	95476	P-I	1	*	*	*	*	*	*	*	0	3	1	*										
m-Xylene	108383	P-I	1	*	*	*	*	3	*	*	0	1	*	*										
p-Xylene	106423	P-I	1	*	*	*	*	*	*	*	0	3	*	*										
Zinc	7440666	P-I	2	*	7	*	*	*	N-A	0	*	2	3	*										

the EMPPL a limited review of the literature was conducted because of the short time available. A larger amount of toxicological information could be obtained through a more exhaustive review. In addition, little information exists on the chemical composition of industrial and municipal effluents in general and Ontario effluents in particular. Thus, many of the chemicals identified through the chemical identification stage were not assessed due to limited data. These chemicals have been prioritized for future review.

4.2.2. Uncertainties in Assessments

The hazard assessments from other jurisdictions may have been developed to meet the specific needs and objectives of those jurisdictions. Chemical assessments incorporating interpretation and judgement by such agencies were accepted without a full review. Difficulties also arise in using new methods that have not been fully tested.

The MOE assessments used readily available information, predominantly from secondary literature. The use of original studies is preferable. The assessment criteria (Tables 1 and 2) were set by Task Force consensus. However, the criteria used in developing the EMPPL are adequate for developing environmental monitoring lists at this time.

5.0 PROCESS FOR FURTHER DEVELOPMENT OF THE ONTARIO EFFLUENT MONITORING PRIORITY POLLUTANTS LIST

5.1 FUTURE REVISIONS

Future revisions of the EMPPL will involve the following where practical:

- further development of the data base
- detailed hazard assessment
- information feedback from subsequent monitoring
- modification and updating as new information becomes available
- mechanisms for external review and input.

A framework which consists of chemical identification and hazard assessment stages is outlined in Figure 2. In addition, the Priority Substances Advisory Committee has been established to advise on the future development of the EMPPL.

5.1.1. Chemical Identification

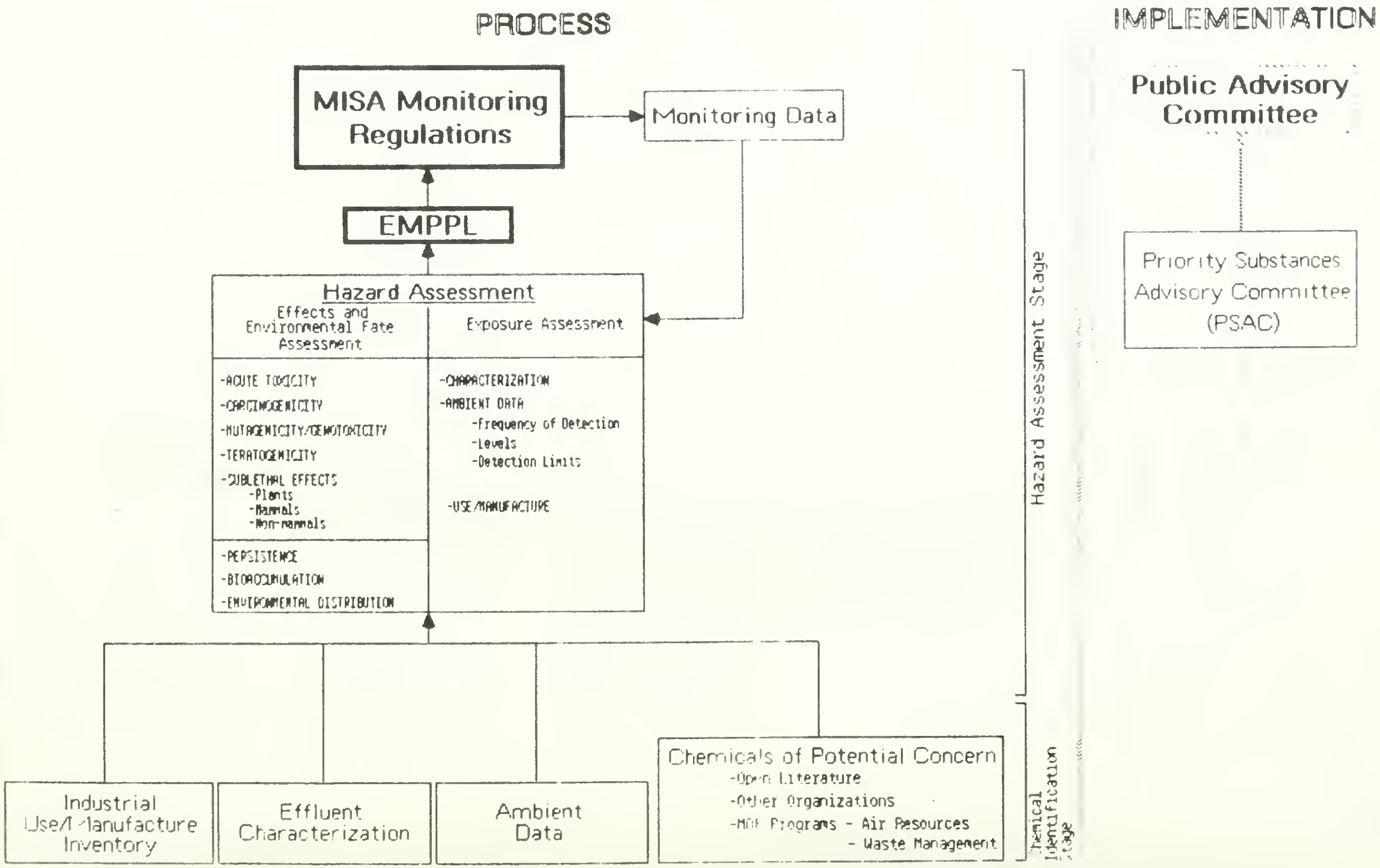
The chemical identification stage used in developing the EMPPL will be refined and expanded in the following areas.

a) Effluent Characterization

Data on the presence of chemicals in Ontario effluents is limited. Gas chromatography/mass spectrometry analyses for organics and trace metal scans can provide more data and reduce the reliance on data from other jurisdictions,

FIGURE 2

PROCESS FOR FURTHER DEVELOPMENT OF THE EFFLUENT MONITORING PRIORITY POLLUTANTS LIST (EMPPL)



which may not be representative of discharges in Ontario. Such open characterization is a complex undertaking and will be conducted according to the analytical principles and guidelines being developed as part of the MISA initiative.

b) Ambient Monitoring Data and Chemicals of Potential Concern

Current Ministry efforts will provide broader and more reliable data on the occurrence of chemicals in the environment. New chemicals identified by ambient monitoring programs will be considered as candidates for the EMPPL.

Other programs within the Ministry, such as the waste generator registration program and proposed changes to Regulation 308, if accepted, will identify additional chemicals to be considered for hazard assessment and possible inclusion on the EMPPL.

c) Industrial Use/Manufacture Inventory

Manufacture and use patterns can indicate possible presence in effluents of chemicals of potential concern but lacking adequate analytical protocols for effluent/ambient monitoring. Such information can be obtained through collaborative efforts with industry or by using formal mechanisms available through federal and provincial legislation.

5.1.2 Hazard Assessment

The parameters used for the assessment of the effects and environmental fate of chemicals in the development of the 1987 EMPPL will continue to be utilized. An additional parameter has been developed for environmental distribution. Details of this parameter are outlined in Appendix A. Further refinements will be made as necessary and in concert with current Ministry activities in this area.

The information used in the 1987 approach for the assessment of exposure will be augmented by monitoring data and effluent characterization data. The assessment will examine frequency of detection, detection limits and levels of occurrence.

The use of a weight-of-evidence approach, rather than a worst-plausible-case approach, will be considered for future hazard assessments. The latter was frequently used in assessing chemicals for the 1987 list. In addition, an increasing amount of information on toxicology and environmental fate of chemicals is being generated by a multitude of organizations, world-wide. This information will be taken into account to ensure that the EMPPL reflects current knowledge. The information will be entered into the Hazardous Contaminants Coordination Branch's database, which is currently under development.

5.2. IMPLEMENTATION OF PROCESS

The Priority Substances Advisory Committee (PSAC) has been established to provide advice on the further development of the EMPPL. One function of this Committee is to consider listing/de-listing requests. The MISA Advisory Committee or a proposed advisory committee on environmental standards will be requested to review the recommendations made by the PSAC. This review process is consistent with the committment of the Government of Ontario to public consultation.

BIBLIOGRAPHY

1. "MISA: Petroleum Refineries' Trace Contaminants", 1986. [Ontario Petroleum Association for the Ontario Ministry of the Environment, Toronto (unpublished)].

2. Ontario Ministry of the Environment and Environment Canada, 1987. "Iron and Steel List". Ontario Ministry of the Environment, Water Resources Branch, Toronto and the West Central Region, Hamilton [unpublished]. [Includes 1984-85 monitoring data for steel and municipal effluents in Hamilton Harbour].

3. Cherwinsky, C. and D. Murray, 1986. Preliminary Investigation of Trace Contaminants in Pulp and Paper Mill Effluents. Ontario Ministry of the Environment, Water Resources Branch, Toronto. pp. 16-29.

4. Canviro Consultants Ltd., 1985. Development of a Strategy and Implementation Costs for Monitoring Hazardous Contaminants in Ontario Municipal Effluents and Sludges: Final Report. Canviro Consultants Ltd., Toronto.

5. Kauss, P., 1986. "St. Mary's River MISA Pilot Site Investigation". Ontario Ministry of the Environment, Great Lakes Section, Toronto [unpublished].

6. Environment Canada and the Ontario Ministry of the Environment, 1986. St. Clair River Pollution Investigation (Sarnia Area). Prepared under the auspices of the Canada-Ontario Agreement respecting Great Lakes Water Quality. [Environment Canada and the Ontario Ministry of the Environment, Toronto].

7. G. Johnson and Y. Hamdy, 1987. St. Clair River MISA Pilot Site Investigation: Volume I - Parts I and II. Ontario Ministry of the Environment, Great Lakes Section, Toronto.

8. Kauss, P.B., Y.S. Hamdy and B.S. Hamma, 1987. "Assessment of Water, Sediment and Biota in the Cornwall, Ontario and Massena, New York Section of the St. Lawrence River 1979-1982". Ontario Ministry of the Environment, Great Lakes Section, Toronto [unpublished].

9. Ontario Ministry of the Environment, 1986. Octadioxins and Octafurans Detected in DOW Sewers and Dump. Issue Report, May 15, 1986. Ontario Ministry of the Environment, Communications Branch, Toronto.

10. Ontario Ministry of the Environment, 1986. "Drinking Water Surveillance Program: Water Treatment Plant Intake List". Ministry of the Environment, Water Resources Branch, Toronto [unpublished].

11. Great Lakes Water Quality Board, 1987. "Working List of Chemicals in the Great Lakes Basin". In 1986 Annual Report on Great Lakes Water Quality, International Joint Commission, Windsor, Ontario.

12. The Niagara River Toxics Committee, 1984. Report of the Niagara River Toxics Committee. The Niagara River Toxics Committee [Ontario Ministry of the Environment, Environment Canada, U.S. Environmental Protection Agency (Region 2) and the New York State Department of Environmental Conservation]. pp. 6.11-6.19.

13. Ontario Ministry of the Environment, 1982. Hazardous Contaminants Program: Chemical Identification. Ontario Ministry of the Environment, Toronto.

14. United States Environmental Protection Agency, 1981. "Treatability Data". In Treatability Manual, Vol. I, U.S. Environmental Protection Agency, Office of Research and Development, Washington, D.C.

16. United States Environmental Protection Agency, 1984. Development Document for Effluent Limitations Guidelines and Standards for the Plastics Moulding and Forming Point Source Category. U.S. Environmental Protection Agency, Office of Water Regulations and Standards, Industrial Technology Division, Washington, D.C. (EPA-440-/1-84-069. Available from NTIS, PB85-186823).

18. Michigan Department of Natural Resources, 1980. Michigan Critical Materials Register. Michigan Department of Natural Resources, Lansing, Michigan. (Document Number 4833-5324).

19. International Agency for Research on Cancer, 1982. Chemicals, Industrial Processes and Industries Associated with Cancer in Humans, IARC Monographs, Volume 1 to 29. IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans, Supplement 4, IARC, Lyon: 17-22.

20. National Library of Medicine, 1987. "Hazardous Substances Data Bank". Computer database distributed by the National Library of Medicine (NLM) Bethesda, MD.

21. Environment Canada, 1981. "Industrial Effluent Survey Bakelite Thermostats Ltd., Belleville, Ontario, November 2-5, 1981". Final Report. Environment Canada, Environmental Protection Service, Toronto [unpublished].

22. Bursey, J.T. and E.D. Pellizzari, 1983. Analysis of Industrial Wastewater for Organic Pollutants in Consent Decree Survey. United States Environmental Protection Agency, Environmental Research Laboratory, Athens Ga. (EPA-68-03-2867. Available from NTIS, PB83-220103).

23. Feiler, H., 1980. Fate of Priority Pollutants in Publicly Owned Treatment Work: Documentation for TOXET Data Set. United States Environmental Protection Agency, Washington, D.C. (EPA-400/1-79-301. Available from NTIS, PB81-238024).

24. Edward Jordan Co. Inc., 1982. Fate of Priority Pollutants in Publicly Owned Treatment Works. U.S. Environmental Protection Agency, Effluent Guidelines Division, Washington, D.C. (EPA-440/1-82/302. Available from NTIS, PB82-263880).

25. Levins, P., J. Adams, P. Brenner, S. Coons, G. Harris, C. Jones, K. Thrun and A. Wechsler, 1979. Sources of Toxic Pollutants Found in Influents to Sewage Treatment Plants. VI Integrated Presentation. U.S. Environmental Protection Agency, Washington, D.C. (EPA-440/4-81-008. Available from NTIS, PB81-219685).

26. Bishop, D.F., 1982. Role of Municipal Wastewater Treatment in Control of Toxics. U.S. Environmental Protection Agency, Municipal Environmental Research Laboratory, Cincinnati, Ohio. (EPA-600/D-82-360. Available from NTIS, PB83-152447).

27. Novak, R.A., J.F. Ryan, M.M. McKown and W.C. Warren, 1978. "Analysis of Screening and Verification EPA Consent Decree Samples from the Pulp and Paper Industry". National Meeting American Chemical Society, Division of Environmental Chemistry 18(2): 580-581.

28. Lue-Hing, C., D.T. Lordi and N.P. KeLada, 1981. "Fate of Priority Pollutants in Large Municipal Treatment Plants". AICHE Symposium Series 77(209): 144-150.

29. Ellis, D.D., C.M. Jones, R.A. Larson and D.J. Schaeffer, 1982. "Organic Constituents of Mutagenic Secondary Effluents from Wastewater Treatment Plants". Archives of Environmental Contamination and Toxicology 11: 373-382.

31. Ongerth, J.E., 1980. "Pretreatment of Industrial Discharges to Publicly Owned Treatment Works". Journal of the Water Pollution Control Federation 52(8): 310-321.

32. Langer, B.S. and H.D. Feiler, 1982. "Residuals Generation and Management in Selected Chemical Industries". Environmental Progress 1(1): 8-16.

33. Snider, E.H. and F.S. Manning, 1982. "A Survey of Pollutant Emission Levels in Wastewaters and Residuals from the Petroleum Refining Industry". Environment International 7: 237-258.

34. Colley, J.D., C.A. Muela, M.L. Owen, N.P. Meserole and J.B. Riggs, 1978. Assessment of Technology for Control of Toxic Effluents from the Electric Utility Industry. U.S. Environmental Protection Agency, Industrial Environmental Lab., N.C. (EPA-600/7-78-090. Available from NTIS, PB283-716).

36. Brisbin, T.D., S.H. Ahn, R.I. Foster, S.A. Labunski and J.A. Olica, 1984. Priority Pollutants in the Cedar Creek Waste Water Reclamation - Recharge Facilities. U.S. Environmental Protection Agency, Municipal Environmental Research Laboratory, Cincinnati, Ohio. (EPA-600/2-84-061. Available from NTIS, PB84-159904).

38. Corpus Information Services, 198-. CPI Product Profiles. Corpus, Don Mills, Ontario.

39. Southam Business Publications, 1986. 1986 Chemical Buyers Guide. Southam Business Publications, Don Mills.

40. Ontario Ministry of the Environment, 1986. Municipal-Industrial Strategy for Abatement (MISA): A Policy and Program Statement of the Controlling Municipal and Industrial Discharges into Surface Waters. Ministry of the Environment, Toronto.

42. Environment Canada, 1985. "Industrial Effluent Survey Celanese Canada Inc.: Millhaven Plant, Kingston, Ontario, November 23-26, 1981". Final Report. Environment Canada, Environmental Protection Service, Ontario Region, Toronto [unpublished].

43. Environment Canada, 1985. "1980-81 Cornwall Point Source Survey". Final Report. Environment Canada Environmental Protection Service, Ontario Region, Pollution Abatement Division, Toronto [unpublished].

44. The Canadian Chemical Producers Association, 1983. "The Ontario Industrial Chemical Survey: An Aggregate Survey of Selected Industrial Chemicals". Prepared for the Ontario Ministry of the Environment, Hazardous Contaminants and Coordination Branch, Toronto [unpublished].

45. Ontario Ministry of the Environment. 1986. Dioxin Test Results from Ontario Pulp and Paper Mills. News release, July 17, 1986. Ontario Ministry of the Environment, Toronto.

46. B.C. Research, 1984. "Chlorinated Organics in Chlorination Stage Effluents from Canadian Pulp Mills". Prepared for Environment Canada, Environmental Protection Service, Hull, Quebec [unpublished].

47. Munro, J.R., M.G. Foster, J. Pawson, A. Stelzig, T. Tseng and L. King, 1985. St. Clair River Point Source Survey 1979-1980. Ontario Ministry of the Environment and Environment Canada, Toronto.

48. Dalrymple, R., 1985. "Canadian Point Sources to the Niagara River: Final Report on MOE and EPS 1981/82 Surveys". Ontario Ministry of the Environment, Toronto and Environment Canada, Ontario Region, Pollution Abatement Division, Toronto [unpublished].

50. King, L., 1986. "1984 Tetraethyl Lead Plant Survey: Ethyl Corporation of Canada Ltd., Corunna, Ontario". Environment Canada, Environmental Protection Service, Ontario Region, Pollution Abatement Division, Toronto [unpublished].

51. CanTox Inc., SENES Consultants Ltd. and the Ontario Ministry of the Environment, 1986. "Vector Scoring System for the Prioritization of Chemical Contaminants, Part I". Ontario Ministry of the Environment, Hazardous Contaminants and Coordination Branch, Toronto [unpublished].

52. Forsht, E.H., 1983. Development Document for Proposed Effluent Limitations Guidelines and New Source Performance Standards for the Organic Chemicals and Plastics and Synthetic Fibers Point Source Category, Volume 2. U.S. Environmental Protection Agency, Washington, D.C. (EPA-440/1-83-009B. Available from NTIS, PB83-205641).

53. Young, D.R., 1978. Priority Pollutants in Municipal Wastewaters. In Annual Report, Coastal Water Research Project, W. Bascon (editor), Southern California Coastal Water Research Project, Long Beach, CA. (Report number SCCWRO AR5-78. Available from NTIS, PB-299830). pp. 103-112.

54. Feiler, H.D., P.J. Storch, and A. Shattuck, 1981. "Treatment and Removal of Priority Industrial Pollutants at Publicly Owned Treatment Works. Proceedings of the Conference on Combined Municipal/Industrial Waste Water Treatment, held at the University of Texas at Dallas on March 25-27, 1980, Aharon Netzer (editor), U.S. Environmental Protection Agency, Ada, Oklahoma. (EPA-600/9-81-021. Available from NTIS, PB83-142414). pp. 414-487.

55. Ontario Ministry of the Environment. "Ontario's Programs for Environmental Management of Dioxins and Furans". Facts, October 21, 1986. Ministry of the Environment, Toronto.

56. B.C. Research, 1979. Biological Characteristics of Pulp Mill Effluent (Part I). Prepared for Environment Canada, Environmental Protection Service, Vancouver, B.C. (CPAR Project Report 678-1).

57. Zukovs, G., R.J. Rush, and M. Gamble, 1984. "Removal of Hazardous Contaminants in the Hamilton Water Pollution Control Plant". Proceedings: Technology Transfer Conference No. 5, (Part I, General Research), Ontario Ministry of the Environment, Toronto. pp. 385-419.

Note: Bibliography for Effects and Environmental Fate Assessments

Information for the effects and environmental fate assessments using the MOE criteria was obtained from approximately 20 secondary sources. Both computerized databases and readily available handbooks were used. The references used for each chemical assessment are on file with the Ministry.

APPENDIX A

ASSESSMENT METHODOLOGIES EMPLOYED BY THE MISA PRIORITY POLLUTANTS TASK FORCE

1.0 Michigan Department of Natural Resources Critical Materials Register (CMR)

2.0 Niagara River Toxics Committee Assessment Criteria (NRTC)

3.0 Ontario Ministry of the Environment Chemical Assessment Criteria (MOE)

1.0 MICHIGAN DEPARTMENT OF NATURAL RESOURCES CRITICAL MATERIALS REGISTER (CMR)

Extracted in total from:

Michigan. Department of Natural Resources. Environmental Services Division. 1980. *Critical Material Register.* [Department of Natural Resources, Lansing].

NOTE:

The 1980 version of the CMR and its associated criteria and rationale as reproduced in this Appendix, are currently going through an extensive review and re-evaluation process. It is expected that this review will result in changes to both the criteria and their associated rationale in the subsequent version of the CMR. Communications with the staff of the Michigan Department of Natural Resources indicate that this re-evaluation should not drastically change the current composition of the CMR; however, additional chemicals may be added.

MICHIGAN CRITICAL MATERIALS REGISTER

1980

Michigan Department of Natural Resources
Environmental Protection Bureau
Environmental Services Division
P. O. Box 30028
Lansing, Michigan 48909

This report was prepared by the Hazard Assessment Unit of the Office of Toxic Materials Control. Any questions or comments should be directed to the staff of this unit at the address on the title page, or at telephone (517) 374-9640.

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SUMMARY

Pursuant to Act 293, P.A. 1972, an amendment to Act 245, P.A. 1929, the Michigan Water Resources Commission was authorized to develop a Register of Critical Materials which are or may be used and/or discharged in Michigan. The development of the Register is based on extensive review of the scientific literature on physical, chemical, and toxicological properties of industrial, pharmaceutical and agricultural chemicals. Advice on establishment and subsequent revisions of the Register comes from an advisory committee composed of environmental specialists from academia, industry, government, and special interest groups. Chemicals selected for review include chemicals with well recognized high toxicity (e.g. PCB's, mercury, cyanide, etc.), those from various lists of priority chemicals developed by NIOSH, EPA, etc., and chemicals of specific concern in Michigan. The review process utilizes a hazard assessment methodology which considers acute toxicity, carcinogenicity, mutagenicity, teratogenicity, persistence, bioaccumulation, and other adverse effects (including subacute and chronic toxicity, feto- or embryotoxicity, phytotoxicity and aesthetics). Chemicals are numerically scored as to their hazard and those posing a high environmental concern (i.e. high score) are inlcuded in the Register. The Register is revised and updated annually as additional information about these chemicals becomes available.

Every business within the State using Critical Materials and discharging to the waters of the State or discharging process waste in addition to sanitary waste to a sewer system must file an annual report on Critical Materials use and discharge. This information is then used for protection of the environment and human health through water pollution control programs.

INTRODUCTION

Act 245, Public Acts (P.A.) of 1929, as amended by Acts 200 and 293, P.A. 1970 and 1972, respectively, provides for annual reporting of wastewater discharge, and use and discharge of materials which appear on a Register of Critical Materials. Annual reports are required from every person doing business in Michigan who discharges wastewater to: 1) the waters of the State, or 2) any sewer system if the wastewater contains process wastes in addition to sanitary sewage. The Act provides for an advisory committee of environmental specialists to assist in compilation of the Register. Historically, the Act delegated authority to the Water Resources Commission to implement this program. This authority has since been transferred to the Director of the Department of Natural Resources (DNR) by executive order. The "Wastewater Report Forms and Instructions" booklet including the enabling legislation is available upon request from the Office of Toxic Materials Control.

The original Critical Materials Register (CMR) compiled in 1971 contained 73 compounds and classes of compounds (Table 1). These compounds were selected because of their toxicity to organisms or aesthetic problems at concentrations of 5 ppm or less. The CMR was revised in 1972 and was reduced to 62 compounds and classes (Table 2). No changes were made in the Register between 1973 and 1976 (Table 3).

Table 1. Michigan Critical Materials Register, 1971.

MICHIGAN WATER RESOURCES COMMISSION

*CRITICAL MATERIALS REGISTER

I. INORGANIC MATERIALS (but including organic derivatives)

Classes of inorganic compounds:

A. Cations

- Antimony
- Arsenic
- Cadmium
- Chromium
- Copper
- Lead
- Mercury
- Nickel
- Selenium
- Silver
- Thallium
- Tin
- Zinc

B. Anions

- Azides
- Cyanides
- Sulfides

II. ORGANIC MATERIALS

A. Toxic to humans and/or fish at 5 ppm or less:

1. Organic compounds:

- Abietic Acid
- Acridine
- Acrolein
- Beta propriolactone
- Benzene
- Benzaldehyde
- Benzyl Bromide
- Dichloropropane
- Diethylbenzene
- Dimethyl dioxane
- Dioxane
- Hydroquinone
- Lactonitrile
- Mesityl Oxide
- Naptholic Acid
- Napthol
- Napthenic Acid
- Oleic Acid
- Peracetic Acid
- Phenanthrene
- Quinoline
- Quinone
- Turpentine
- Polychlorinated Biphenyls
- Hexachlorobenzene
- Hexachlorobutadiene

2. Classes of organic compounds:

- Amines
- Anilines
- Butyraldehydes
- Chlorinated Benzene Compounds
- Ether containing compounds
- Nitrobenzenes
- Phenolic compounds
- Phthalates
- Pyridines
- Silanes

B. Cause aesthetic problems at 5 ppm or less (i.e., taste and odor).

Compounds

- Amyl Acetate
- Butyl Alcohol
- Butyric Acid
- Carbon Disulfide
- Crotonaldehyde
- Cumene
- Ethyl Acrylate
- Isoprene
- Mesitylene
- Styrene
- Vinyl Toluene

Classes of compounds

- Picramates
- Xylenes

III. PESTICIDES, HERBICIDES AND FUNGICIDES

Herbicides

- Tordon
- 2-4-5 T(and its formulations)

Pesticides

- Aldrin
- DDT
- Dieldrin
- Endrin
- Heptachlor
- Toxaphene

Table 2. Michigan Critical Materials Register, 1972

Michigan Water Resources Commission
CRITICAL MATERIALS REGISTER
Published November 1, 1972

I. INORGANIC MATERIALS	Parameter Number		Parameter Number
Antimony	95000	Mercury	95006
Arsenic	95001	Nickel	95007
Cadmium	95002	Selenium	95008
Chromium	95003	Silver	95009
Copper	95004	Sulfides	95015
Cyanides	95014	Thallium	95010
Lead	95005	Zinc	95012

II. ORGANIC MATERIALS	Parameter Number		
Acridine	95017	Hexachlorobenzene (HCB)	95040
Acrolein	95018	Hexachlorobutadiene (HCBD)	95041
Aldrin	95067	Hydroquinone	95027
°Ammonia	95089	Isoprene	95059
Amyl Acetate	95052	Lactonitrile	95028
Anilines (incl. Benzidines)	95043	Mesitylene	95060
Benzaldehyde	95021	Mesityl Oxide	95029
Benzene (Solvent)	95020	Napthol	95031
Benzyl Bromide	95022	Naphthenic Acid (Napthalene)	95032
Beta propriolactone	95019	Nitrobenzenes	95047
Butyl Alcohol	95053	Phenolic compounds	95048
Butyraldehydes	95044	Phrenanthrene	95035
Butyric Acid	95054	Phthalates	95049
Carbon Disulfide	95055	Picramates (nitro-phenols)	95063
Chlorinated Benzene Compounds	95045	Polychlorinated biphenyls (PCB's)	95039
Crotonaldehyde	95056	Pyridines	95050
Cumene	95057	Quinoline	95036
DDT	95068	Quinone	95037
Dichloropropane	95023	Styrene	95061
Dieldrin	95069	Tordon	95065
Diethylbenzene	95024	Toxaphene	95072
Endrin	95070	Vinyl Toluene	95062
Ethyl Acrylate	95058	Xylenes	95064
Heptachlor	95071	2-4-5 T (and its formulations)	95066

New entry—initial reporting on this material not required until report due January 1974 (covering 1973 calendar year).

Table 3. Michigan Critical Materials Register, 1976

Michigan Water Resources Commission
CRITICAL MATERIALS REGISTER
Published October 1, 1976

I. INORGANIC MATERIALS	Parameter Number		Parameter Number
Antimony	95000	Mercury	95006
Arsenic	95001	Nickel	95007
Cadmium	95002	Selenium	95008
Chromium	95003	Silver	95009
Copper	95004	Sulfides	95015
Cyanides	95014	Thallium	95010
Lead	95005	Zinc	95012

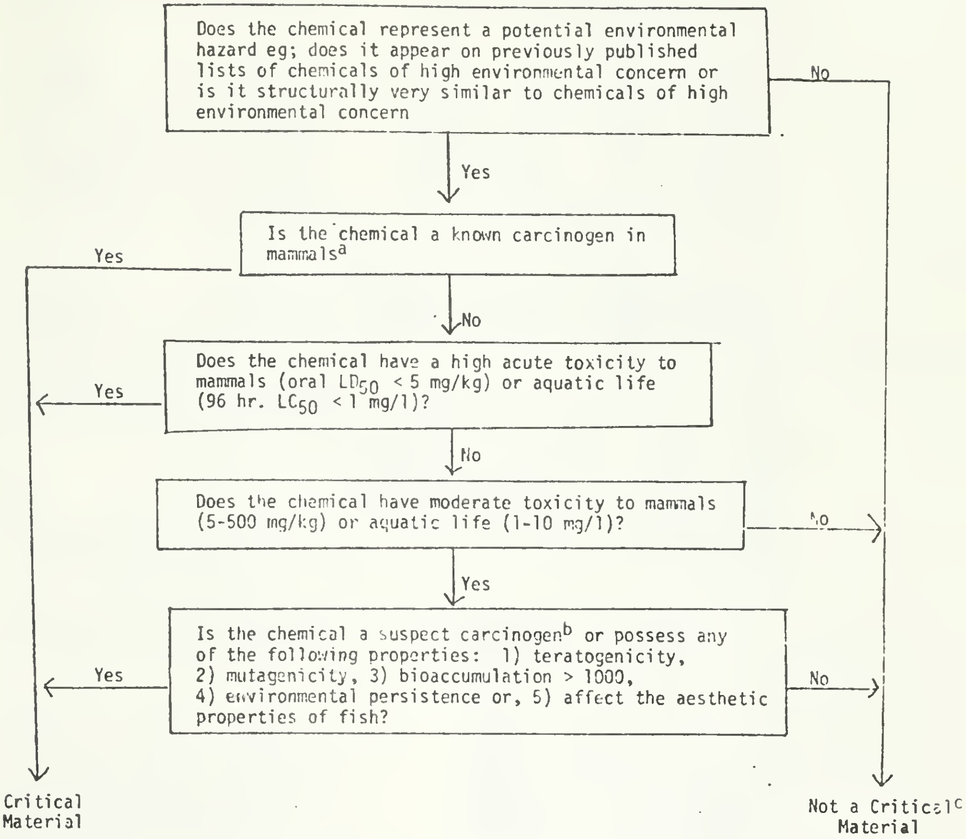
II ORGANIC MATERIALS	Parameter Number		Parameter Number
Acridine	95017	Hexachlorobenzene (HCB)	95040
Acrolein	95018	Hexachlorobutadiene (HCBD)	95041
Aldrin	95067	Hydroquinone	95027
Ammonia	95089	Isoprene	95059
Amyl Acetate	95052	Lactonitrile	95028
Anilines (incl. Benzidines)	95043	Mesitylene	95060
Benzaldehyde	95021	Mesityl Oxide	95029
Benzene (Solvent)	95020	Napthol	95031
Benzyl Bromide	95022	Naphthenic Acid	95032
Beta propriolactone	95019	Nitrobenzenes	95047
Butyl Alcohol	95053	Phenolic compounds	95048
Butyraldehydes	95044	Phenanthrene	95035
Butyric Acid	95054	Phthalates	95049
Carbon Disulfide	95055	Picramates (nitro-phenols)	95063
Chlorinated Benzene Compounds	95045	Polychlorinated biphenyls (PCB's)	95039
Crotonaldehyde	95056	Pyridines	95050
Cumene	95057	Quinoline	95036
DDT	95068	Quinone	95037
Dichloropropane	95023	Styrene	95061
Dieldrin	95069	Picloram	95065
Diethylbenzene	95024	Toxaphene	95072
Endrin	95070	Vinyl Toluene	95062
Ethyl Acrylate	95058	Xylenes	95064
Heptachlor	95071	2-4-5 T (and its formulations)	95066

An extensive revision of the Register along with the methods for evaluating and selecting Critical Materials was made in 1977. A decision was made to move toward development of an objective system for selection and and a model was developed to evaluate chemicals for possible inlcusion (Figure 1). The 1977 CMR (Table 4) contained 218 compounds and classes.

The 1978 evaluation procedure became more objective as the review process was changed from a screening model to a numerically scored hazard assessment system. This system is summarized on the 1978 CMR Hazard Assessment Sheet (Table 5). Eight factors of environmental concern were identified and a point value was assigned to each category within the individual factors. A chemical was included on the 1978 CMR if it receivied a score of seven points in one factor or a cumulative score of seven points or more in several factors. The 1978 CMR (Table 6) contained 190 compounds and classes. The hazard assessment process has been continued in 1979 and 1980 with additional categories reviewed. The 1979 CMR (Table 7) contained 178 compounds and classes.

The CMR is revised and updated on an annual basis in order to be effective. The rapidly changing understanding of toxic substances and numerous new chemicals manufactured each year make an annual review imperative. The review process is initiated about January 1 with DNR staff's development of proposed changes in the hazard assessment process and compilation of a list of chemicals to be reviewed. This information is sent to members of the Critical Materials Advisory Committee for review. Committee meetings are held to discuss these proposals and to finalize the revisions. Concurrently, chemical evaluations of materials selected for review are conducted by DNR staff to gather data for hazard assessment. Assessments are then conducted utilizing the finalized hazard assessment process. The Committee

Figure 1. 1977 Model for Screening and Selecting Critical Materials

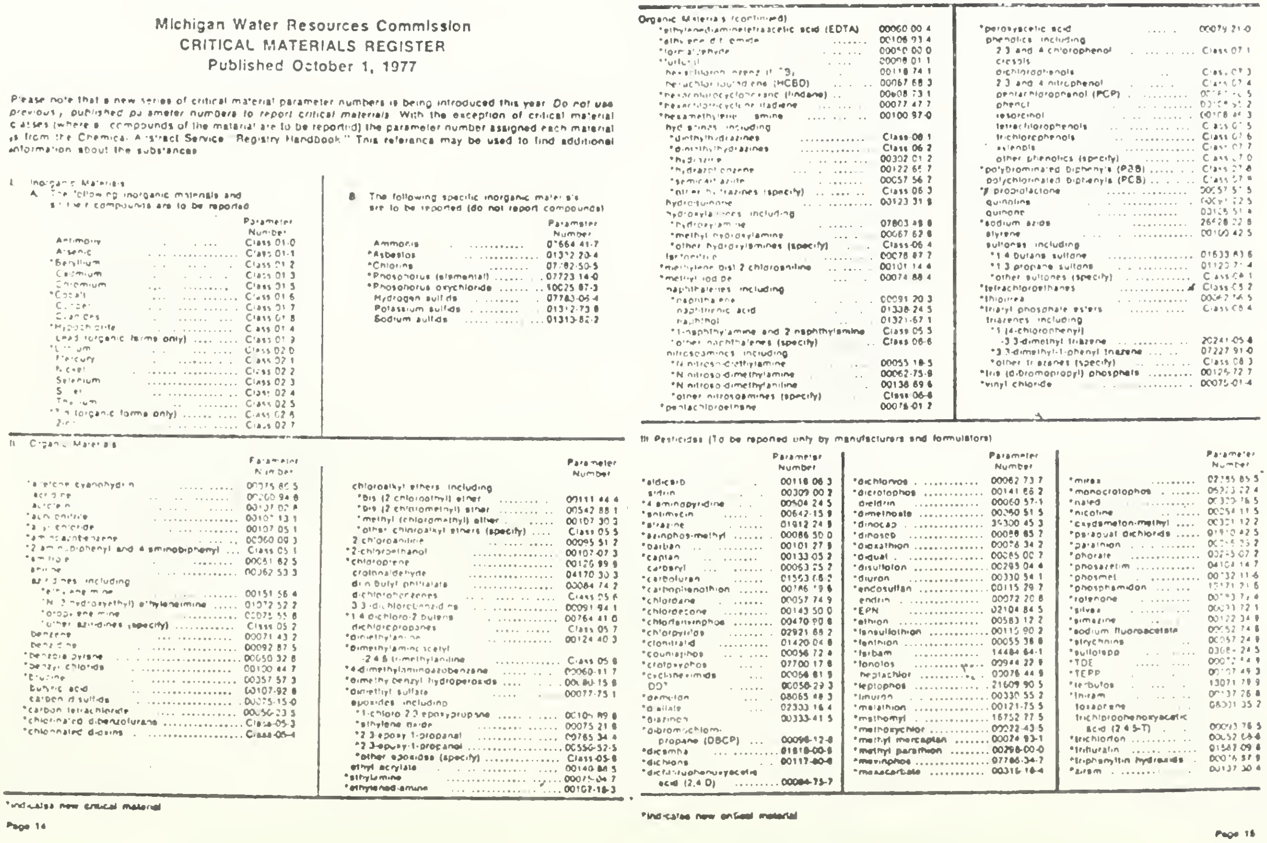

Does the chemical represent a potential environmental hazard eg; does it appear on previously published lists of chemicals of high environmental concern or is it structurally very similar to chemicals of high environmental concern
No
Yes
Is the chemical a known carcinogen in mammals[a]
Yes
No
Does the chemical have a high acute toxicity to mammals (oral LD$_{50}$ < 5 mg/kg) or aquatic life (96 hr. LC$_{50}$ < 1 mg/l)?
Yes
No
Does the chemical have moderate toxicity to mammals (5-500 mg/kg) or aquatic life (1-10 mg/l)?
No
Yes
Is the chemical a suspect carcinogen[b] or possess any of the following properties: 1) teratogenicity, 2) mutagenicity, 3) bioaccumulation > 1000, 4) environmental persistence or, 5) affect the aesthetic properties of fish?
Yes
No
Critical Material
Not a Critical[c] Material

a. A known carcinogen is defined as a chemical meeting one of the following criteria: 1) Appears on the NIOSH carcinogen list 2) has been demonstrated through epidemiological studies to be a human carcinogen 3) has been shown at low doses (1% of LD$_{50}$) to increase tumor production by oral administration in at least two species of animals.

b. A suspect carcinogen is defined as a chemical meeting the following criteria; has been shown to increase tumor production only at high doses (> 1% of LD$_{50}$) or by a route other than oral or in only one species.

c. A chemical not meeting these criteria may still be designated a critical material if the CMR advisory committee determines the compound represents an unreasonable environmental risk due to other factors.

Table 4. Michigan Critical Materials Register, 1977



Michigan Water Resources Commission
CRITICAL MATERIALS REGISTER
Published October 1, 1977

Please note that a new series of critical material parameter numbers is being introduced this year. *Do not use previously published parameter numbers to report critical materials.* With the exception of critical material classes (where all compounds of the material are to be reported) the parameter number assigned each material is from the Chemical Abstract Service "Registry Handbook." This reference may be used to find additional information about the substances.

I. Inorganic Materials

A. The following inorganic materials and all their compounds are to be reported

	Parameter Number
Antimony	Class 01 0
Arsenic	Class 01 1
*Beryllium	Class 01 2
Cadmium	Class 01 3
Chromium	Class 01 5
*Cobalt	Class 01 6
Copper	Class 01 7
Cyanides	Class 01 8
*Hypochlorite	Class 01 4
Lead (organic forms only)	Class 01 9
*Lithium	Class 02 0
Mercury	Class 02 1
Nickel	Class 02 2
Selenium	Class 02 3
Silver	Class 02 4
Thallium	Class 02 5
*Tin (organic forms only)	Class 02 6
Zinc	Class 02 7

B. The following specific inorganic materials are to be reported (do not report compounds)

	Parameter Number
Ammonia	07664 41-7
*Asbestos	01332 20-4
*Chlorine	07782-50-5
*Phosphorus (elemental)	07723 14-0
*Phosphorus oxychloride	10025 87-3
Hydrogen sulfide	07783-06-4
Potassium sulfide	01312-73 8
Sodium sulfide	01313-82-2

II. Organic Materials

	Parameter Number
*acetone cyanohydrin	00075 86 5
acridine	00260 94 6
acrolein	00107 02 8
*acrylonitrile	00107 13 1
*allyl chloride	00107 05 1
*aminoazobenzene	00060 09 3
*2 aminobiphenyl and 4 aminobiphenyl	Class 05 1
*amitrole	00061 82 5
aniline	00062 53 3
aziridines including	
*ethyleneimine	00151 56 4
*N (2 hydroxyethyl) ethyleneimine	01072 52 2
*propyleneimine	00075 55 8
*other aziridines (specify)	Class 05 2
benzene	00071 43 2
benzidine	00092 87 5
*benzo(a)pyrene	00050 32 8
*benzyl chloride	00100 44 7
*brucine	00357 57 3
butyric acid	00107-92 6
carbon disulfide	00075-15-0
*carbon tetrachloride	00056-23 5
*chlorinated dibenzofurans	Class-05-3
*chlorinated dioxins	Class-05-4
chloroalkyl ethers including	
*bis (2 chloroethyl) ether	00111 44 4
*bis (2 chloromethyl) ether	00542 88 1
*methyl (chloromethyl) ether	00107 30 2
*other chloroalkyl ethers (specify)	Class 05 5
2 chloroaniline	00095 51 2
*2-chloroethanol	00107-07 3
*chloroprene	00126 99 8
crotonaldehyde	04170 30 3
di n butyl phthalate	00084 74 2
dichlorobenzenes	Class 05 6
3 3'-dichlorobenzidine	00091 94 1
*1 4 dichloro-2 butene	00764 41 0
dichloropropanes	Class 05 7
*dimethylamine	00124 40 3
*dimethylaminoacetyl -2 4 6 trimethylaniline	Class 05 8
*4-dimethylaminoazobenzene	00060-11 7
*dimethyl benzyl hydroperoxide	00080-15 9
*dimethyl sulfate	00077-78 1
epoxides including	
*1-chloro 2 3 epoxypropane	00106 89 8
*ethylene oxide	00075 21 8
*2 3-epoxy 1-propanal	00765 34 4
*2 3-epoxy-1-propanol	00556-52-5
*other epoxides (specify)	Class-05-9
ethyl acrylate	00140-88 5
*ethylamine	00075-04 7
*ethylenediamine	00107-15-3

*indicates new critical material

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Organic Materials (continued)

	Parameter Number
*ethylenediaminetetraacetic acid (EDTA)	00060 00 4
*ethylene dibromide	00106 93 4
*formaldehyde	00050 00 0
*furfural	00098 01 1
hexachlorobenzene (HCB)	00118 74 1
hexachlorobutadiene (HCBD)	00087 68 3
*hexachlorocyclohexane (lindane)	00608 73 1
*hexachlorocyclopentadiene	00077 47 4
*hexamethylenetetramine	00100 97-0
hydrazines including	
*diethylhydrazines	Class-06 1
*dimethylhydrazines	Class 06 2
*hydrazine	00302 01 2
*hydrazobenzene	00122 66 7
*semicarbazide	00057 56 7
*other hydrazines (specify)	Class 06 3
hydroquinone	00123 31 9
hydroxylamines including	
*hydroxylamine	07803 49 8
*methyl hydroxylamine	00067 62 9
*other hydroxylamines (specify)	Class-06 4
isophorone	00078 87 7
*methylene bis(2 chloroaniline)	00101 14 4
*methyl iodide	00074 88 4
naphthalenes including	
*naphthalene	00091 20 3
naphthenic acid	01338-24 5
naphthol	01321-67 1
*1-naphthylamine and 2 naphthylamine	Class 06 5
*other naphthalenes (specify)	Class 06-6
nitrosamines including	
*N nitroso-diethylamine	00055 18-5
*N nitroso-dimethylamine	00062-75-9
*N nitroso-dimethylaniline	00138 89 6
*other nitrosamines (specify)	Class 06-8
*pentachloroethane	00076-01 7
*peroxyacetic acid	00079 21-0
phenolics including	
2 3 and 4 chlorophenol	Class 07 1
cresols	
dichlorophenols	Class 07 3
2 3 and 4 nitrophenol	Class 07 4
pentachlorophenol (PCP)	00087 86 5
phenol	00108 95 2
resorcinol	00108 46 3
tetrachlorophenols	Class 07 5
trichlorophenols	Class 07 6
xylenols	Class 07 7
other phenolics (specify)	Class 07 0
*polybrominated biphenyls (PBB)	Class 07 8
polychlorinated biphenyls (PCB)	Class 07 9
*β propiolactone	00057 57 8
quinoline	00091 22 5
quinone	00106 51 4
*sodium azide	26628 22 8
styrene	00100 42 5
sultones including	
*1 4 butane sultone	01633 83 6
*1 3 propane sultone	01120 71 4
*other sultones (specify)	Class 08 1
*tetrachloroethanes	Class 08 2
*thiourea	00062 56 6
*triaryl phosphate esters	Class 08 4
triazenes including	
*1 (4-chlorophenyl) -3 3-dimethyl triazene	20241-05-4
*3 3-dimethyl-1-phenyl triazene	07227 91-0
*other triazenes (specify)	Class 08 3
*tris (dibromopropyl) phosphate	00126-72 7
*vinyl chloride	00075-01-4

III. Pesticides (To be reported only by manufacturers and formulators)

	Parameter Number
*aldicarb	00116 06 3
aldrin	00309 00 2
*4 aminopyridine	00504 24 5
*antimycin	00642-15 9
*atrazine	01912 24 9
*azinphos-methyl	00086 50 0
*barban	00101 27 9
*captan	00133-06 2
carbaryl	00063 25 2
*carbofuran	01563 66 2
*carbophenothion	00786 19 6
*chlordane	00057 74 9
*chlordecone	00143 50 0
*chlorfenvinphos	00470 90 6
*chlorpyrifos	02921 88 2
*clonitralid	01420 04 8
*coumaphos	00056 72 4
*crotoxyphos	07700 17 6
*cycloheximide	00066 81 9
DDT	00050-29 3
*demeton	08065 48 3
*diallate	02303 16 4
*diazinon	00333-41 5
*dibromochloro-propane (DBCP)	00096-12-8
*dicamba	01918-00-9
*dichlone	00117-80-6
*dichlorophenoxyacetic acid (2,4 D)	00094-75-7
*dichlorvos	00062 73 7
*dicrotophos	00141 66 2
dieldrin	00060 57-1
*dimethoate	00060 51 5
*dinocap	39300 45 3
*dinoseb	00088 85 7
*dioxathion	00078 34 2
*diquat	00085 00 7
*disulfoton	00298 04 4
*diuron	00330 54 1
*endosulfan	00115 29 7
endrin	00072 20 8
*EPN	02104 64 5
*ethion	00563 12 2
*fensulfothion	00115 90 2
*fenthion	00055 38 9
*ferbam	14484 64-1
*fonofos	00944 22 9
heptachlor	00076 44 8
*leptophos	21609 90 5
*linuron	00330 55 2
*malathion	00121-75 5
*methomyl	16752 77 5
*methoxychlor	00072-43 5
*methyl mercaptan	00074 93-1
*methyl parathion	00298-00-0
*mevinphos	07786-34-7
*mexacarbate	00315-18-4
*mirex	02385 85 5
*monocrotophos	06923 22 4
*naled	00300 76 5
*nicotine	00054 11 5
*oxydemeton-methyl	00301 12 2
*paraquat dichloride	01910 42 5
*parathion	00056 38 2
*phorate	00298-02 2
*phosazetim	04104 14 7
*phosmet	00732 11-6
*phosphamidon	13171 21 6
*rotenone	00083 79 4
*silvex	00093 72 1
*simazine	00122 34 9
*sodium fluoroacetate	00062 74 8
*strychnine	00057 24 9
*sulfotepp	03689 24 5
*TDE	00072 54 8
*TEPP	00107 49 3
*terbufos	13071 79 9
*thiram	00137 26 8
toxaphene	08001 35 2
trichlorophenoxyacetic acid (2 4 5-T)	00093 76 5
*trichlorfon	00052 68-6
*trifluralin	01582 09 8
*triphenyltin hydroxide	00076 87 9
*ziram	00137 30 4

*indicates new critical material

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Table 5. 1978 Critical Materials Register Hazard Assessment Sheet

CRITICAL MATERIALS REGISTER HAZARD ASSESSMENT SHEET

Common Chemical Name ______________________

Chemical Abstract Name ______________________

Chemical Abstract No. ☐☐☐☐☐☐ - ☐☐ - ☐

SCORE

I. Acute Toxicity ______

SCORE	CATEGORY		
	ORAL LD50 mg/kg	DERMAL LD50 mg/kg	AQUATIC 96 HOUR LC50 mg/l
7	< 5	< 5	< 1
3	5-50	5-200	1-10
2	> 50-500	> 200-500	> 10-100
1	> 500-5000	> 500-5000	> 100-1000
0	> 5000	> 5000	> 1000
*	Insufficient Information		

II. Carcinogenicity ______

SCORE	CATEGORY	
7	Human positive Animal positive	human suspect
3	Animal suspect	
2	Carcinogenic by a route other than oral or dermal Strongly potential carcinogen by accepted mutagenicity screening tests or accepted cell transformation studies	
1	Potential carcinogen by accepted mutagenicity screening tests or accepted cell transformation studies	
0	Not carcinogenic	
*	Insufficient Information	

III. Hereditary Mutagenicity ______

SCORE	CATEGORY
7	Confirmed
4	Suspect - multicellular organisms
2	Suspect - micro-organisms
0	Not a hereditary mutagen
*	Insufficient Information

IV. Teratogenicity ______

SCORE	CATEGORY
7	Confirmed
3	Suspect
0	Not teratogenic
*	Insufficient Information

V. Persistence ______

SCORE	CATEGORY
4	Very persistent
3	Persistent
2	Slowly degradable
1	Moderately degradable
0	Readily degradable
*	Insufficient Information

VI. Bioaccumulation ______

SCORE	BIOACCUMULATION	LOG P
7	> 4000	> 6.00
3	1000 - 3999	5.00 - 5.99
2	700 - 999	4.50 - 4.99
1	300 - 699	4.00 - 4.49
0	< 300	< 4.00
*	Insufficient Information	

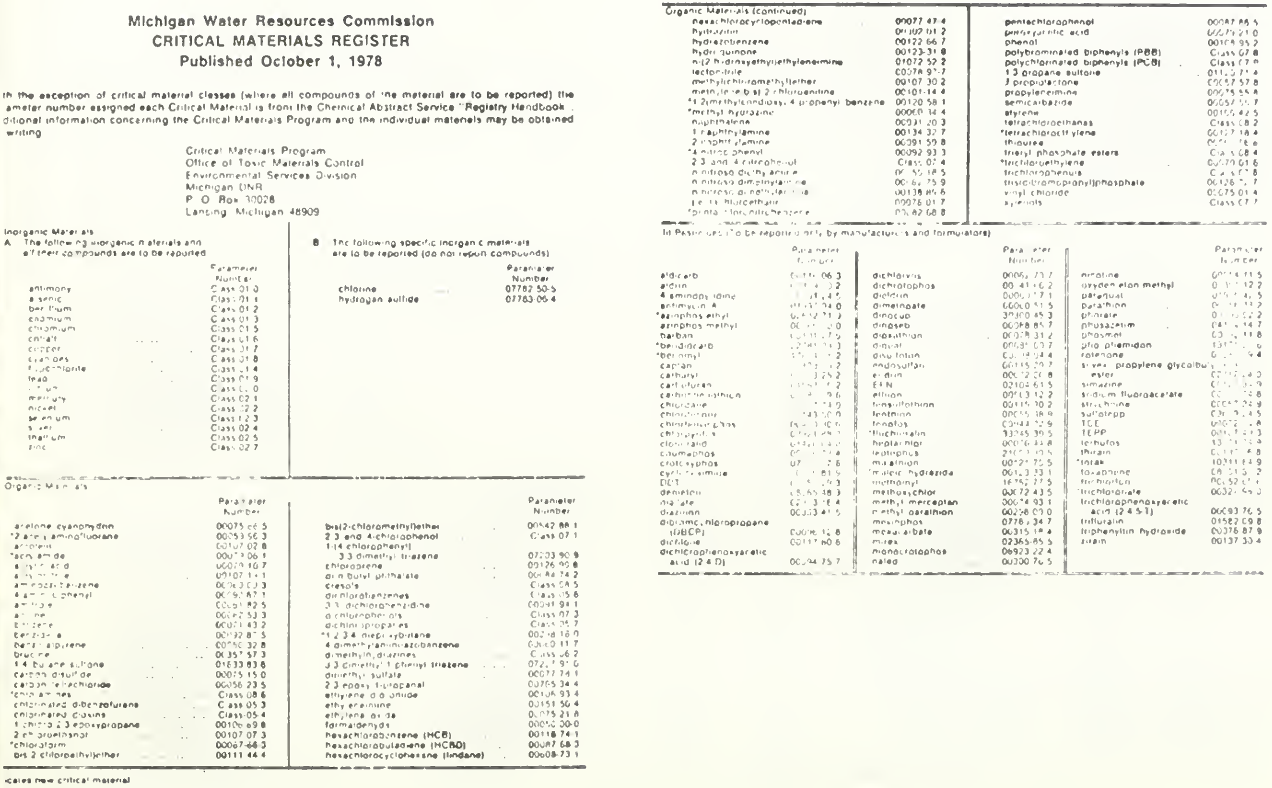
VII. Aesthetics ______

SCORE	CATEGORY	
	Fish Tainting/Tase and Odor (Threshold level in water - mg/l)	Foaming, floating film, and/or major color change
3	0.0001-0.001	
2	> 0.001 -0.01	
1	> 0.01 -0.1	Yes
0	> 0.1	No

VIII. Chronic Adverse Effects ______

SCORE	CATEGORY
4	Irreversible effects
2	Reversible effects
1	Adverse effects by route other than oral, dermal, or aquatic
0	No detectable adverse effects
*	Insufficient Information

Table 6. Michigan Critical Materials Register, 1978



Michigan Water Resources Commission
CRITICAL MATERIALS REGISTER
Published October 1, 1978

th the exception of critical material classes (where all compounds of the material are to be reported) the ameter number assigned each Critical Material is from the Chemical Abstract Service "Registry Handbook". ditional information concerning the Critical Materials Program and the individual materials may be obtained writing

Critical Materials Program
Office of Toxic Materials Control
Environmental Services Division
Michigan DNR
P O Box 30028
Lansing Michigan 48909

Inorganic Materials

A The following inorganic materials and all their compounds are to be reported

	Parameter Number
antimony	Class 01 0
arsenic	Class 01 1
beryllium	Class 01 2
cadmium	Class 01 3
chromium	Class 01 5
cobalt	Class 01 6
copper	Class 01 7
cyanides	Class 01 8
[illegible]	Class 01 4
lead	Class 01 9
[illegible]	Class 02 0
mercury	Class 02 1
nickel	Class 02 2
selenium	Class 02 3
silver	Class 02 4
thallium	Class 02 5
zinc	Class 02 7

B The following specific inorganic materials are to be reported (do not report compounds)

	Parameter Number
chlorine	07782 50-5
hydrogen sulfide	07783-06-4

Organic Materials

	Parameter Number
acetone cyanohydrin	00075 86 5
*2 acetylaminofluorene	00053 96 3
acrolein	00107 02 8
*acrylamide	00079 06 1
acrylic acid	00079 10 7
acrylonitrile	00107 13 1
aminoazobenzene	00060 09 3
4 aminobiphenyl	00092 67 1
amitrole	00061 82 5
aniline	00062 53 3
benzene	00071 43 2
benzidine	00092 87 5
benzo(a)pyrene	00050 32 8
brucine	00357 57 3
1 4 butane sultone	01633 83 8
carbon disulfide	00075 15 0
carbon tetrachloride	00056 23 5
*chloramines	Class 08 6
chlorinated dibenzofurans	Class 05 3
chlorinated dioxins	Class-05-4
1 chloro 2 3 epoxypropane	00106 89 8
2 chloroethanol	00107 07 3
*chloroform	00067-66-3
bis 2 chloroethyl ether	00111 44 4

	Parameter Number
bis(2-chloromethyl)ether	00542 88 1
2 3 and 4-chlorophenol	Class 07 1
1-(4 chlorophenyl) 3 3 dimethyl triazene	07203 90 9
chloroprene	00126 99 8
di n butyl phthalate	00084 74 2
cresols	Class 08 5
dichlorobenzenes	Class 05 6
3 3 dichlorobenzidine	00091 94 1
dichlorophenols	Class 07 3
dichloropropanes	Class 05 7
*1 2 3 4 diepoxybutane	002[illegible] 16 0
4 dimethylaminoazobenzene	00060 11 7
dimethylhydrazines	Class 06 2
3 3 dimethyl 1 phenyl triazene	072[illegible] 91 0
dimethyl sulfate	00077 78 1
2 3 epoxy 1-propanal	00765 34 4
ethylene dibromide	00106 93 4
ethyleneimine	00151 56 4
ethylene oxide	00075 21 8
formaldehyde	00050 00-0
hexachlorobenzene (HCB)	00118 74-1
hexachlorobutadiene (HCBD)	00087 68 3
hexachlorocyclohexane (lindane)	00608-73 1

cates new critical material

Organic Materials (continued)

hexachlorocyclopentadiene	00077 47 4
hydrazine	00302 01 2
hydrazobenzene	00122 66 7
hydroquinone	00123-31 9
n-(2 hydroxyethyl)ethyleneimine	01072 52 2
lactonitrile	00078 97-7
methylchloromethylether	00107 30 2
methylene bis(2 chloroaniline)	00101-14 4
*1 2(methylenedioxy) 4 propenyl benzene	00120 58 1
*methyl hydrazine	00060 34 4
naphthalene	00091 20 3
1 naphthylamine	00134 32 7
2 naphthylamine	00091 59 8
*4 nitrobiphenyl	00092 93 3
2 3 and 4 nitrophenol	Class 07 4
n nitroso diethylamine	00055 18 5
n nitroso dimethylamine	00062 75 9
n nitroso di[illegible]	00138 86 6
pentachloroethane	00076 01 7
*pentachloronitrobenzene	00082 68 8

pentachlorophenol	00087 86 5
peroxyacetic acid	00079 21 0
phenol	00108 95 2
polybrominated biphenyls (PBB)	Class 07 8
polychlorinated biphenyls (PCB)	Class 07 [illegible]
1 3 propane sultone	01120 71 4
β propiolactone	00057 57 8
propyleneimine	00075 55 8
semicarbazide	00057 56 7
styrene	00100 42 5
tetrachloroethanes	Class 08 2
*tetrachloroethylene	00127 18 4
thiourea	[illegible]
triaryl phosphate esters	Class 08 4
*trichloroethylene	00079 01 6
trichlorophenols	Class 0[illegible] 8
tris(dibromopropyl)phosphate	00126 72 7
vinyl chloride	00075 01 4
xylenols	Class 07 7

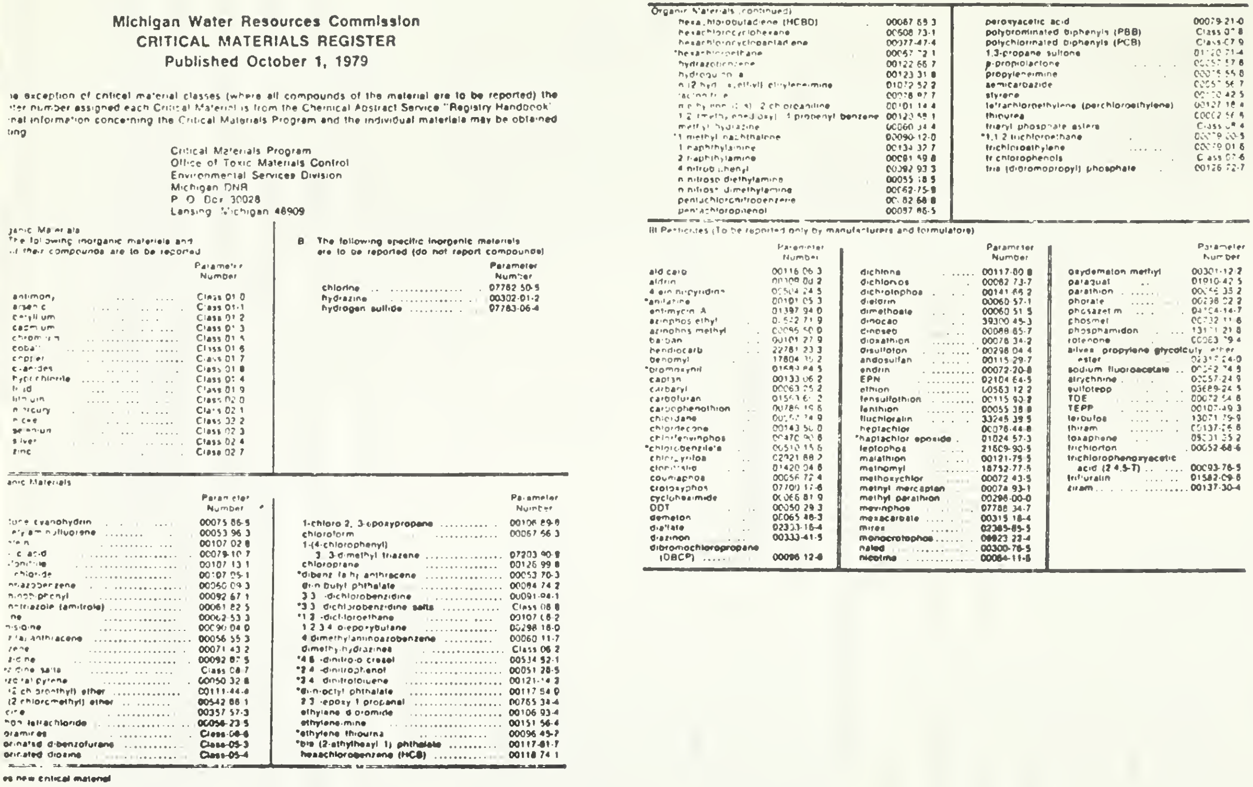
III Pesticides (To be reported only by manufacturers and formulators)

	Parameter Number
aldicarb	00116 06 3
aldrin	[illegible] 2
4 aminopyridine	[illegible]
antimycin A	[illegible] 94 0
*azinphos ethyl	[illegible] 71 9
azinphos methyl	00[illegible] 0
barban	[illegible]
*bendiocarb	[illegible]
*benomyl	[illegible]
captan	[illegible] 2
carbaryl	[illegible] 25 2
carbofuran	[illegible] 2
carbophenothion	[illegible] 6
chlordane	[illegible] 9
chlordecone	[illegible]43 50 0
chlorfenvinphos	[illegible]
chlorpyrifos	[illegible]
clonitralid	[illegible]
coumaphos	[illegible]
crotoxyphos	[illegible] 6
cycloheximide	[illegible] 81 9
DDT	[illegible] 3
demeton	[illegible]65 48 3
diallate	[illegible] 16 4
diazinon	00333 41 5
dibromochloropropane (DBCP)	00096 12 8
dichlone	00117 80 6
dichlorophenoxyacetic acid (2 4 D)	00094 75 7

	Parameter Number
dichlorvos	00062 73 7
dicrotophos	00141 66 2
dieldrin	00060 57 1
dimethoate	00060 51 5
dinocap	39300 45 3
dinoseb	00088 85 7
dioxathion	00078 34 2
diquat	[illegible] 00 7
disulfoton	00298 04 4
endosulfan	00115 29 7
endrin	00072 20 8
EPN	02104 64 5
ethion	00563 12 2
fensulfothion	00115 90 2
fenthion	00055 38 9
fonofos	00944 22 9
*fluchloralin	33245 39 5
heptachlor	00076 44 8
leptophos	21609 90 5
malathion	00121 75 5
*maleic hydrazide	00123 33 1
methomyl	16752 77 5
methoxychlor	00072 43 5
methyl mercaptan	00074 93 1
methyl parathion	00298 00 0
mevinphos	07786 34 7
mexacarbate	00315 18 4
mirex	02385-85 5
monocrotophos	06923 22 4
naled	00300 76 5

	Parameter Number
nicotine	00054 11 5
oxydemeton methyl	[illegible] 12 2
paraquat	[illegible]
parathion	[illegible]
phorate	[illegible]
phosazetim	[illegible] 14 7
phosmet	[illegible] 11 6
phosphamidon	[illegible]
rotenone	[illegible] 4
silvex propylene glycolbutyl ester	[illegible]
simazine	[illegible]
sodium fluoroacetate	[illegible] 8
strychnine	[illegible] 9
sulfotepp	[illegible] 5
TDE	[illegible]
TEPP	[illegible]
terbufos	[illegible]
thiram	[illegible] 8
*torak	10311 84 9
toxaphene	[illegible]
trichlorfon	[illegible]
*trichloronate	[illegible]
trichlorophenoxyacetic acid (2 4 5-T)	00093 76 5
trifluralin	01582 09 8
triphenyltin hydroxide	00076 87 9
ziram	00137 30 4

Table 7. Michigan Critical Materials Register, 1979



Michigan Water Resources Commission
CRITICAL MATERIALS REGISTER
Published October 1, 1979

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Critical Materials Program
Office of Toxic Materials Control
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beryllium	Class 01 2
cadmium	Class 01 3
chromium	Class 01 5
cobalt	Class 01 6
copper	Class 01 7
cyanides	Class 01 8
hypochlorite	Class 01 4
lead	Class 01 9
lithium	Class 02 0
mercury	Class 02 1
nickel	Class 02 2
selenium	Class 02 3
silver	Class 02 4
zinc	Class 02 7

B The following specific inorganic materials are to be reported (do not report compounds)

	Parameter Number
chlorine	07782 50-5
hydrazine	00302-01-2
hydrogen sulfide	07783-06-4

anic Materials

	Parameter Number
tone cyanohydrin	00075 86-5
etylaminofluorene	00053 96 3
lein	00107 02 8
ic acid	00079-10 7
lonitrile	00107 13 1
chloride	00107 05-1
noazobenzene	00060 09 3
nobiphenyl	00092 67 1
notriazole (amitrole)	00061 82 5
ne	00062-53 3
nisidine	00090 04 0
z (a) anthracene	00056 55 3
zene	00071 43 2
zidine	00092 87 5
zidine salts	Class 08 7
zo (a) pyrene	00050 32 8
(2 chloroethyl) ether	00111-44-4
(2 chloromethyl) ether	00542 88 1
cine	00357 57-3
bon tetrachloride	00056-23 5
oramines	Class 08-6
orinated dibenzofurans	Class 05-3
orinated dioxins	Class 05-4

	Parameter Number
1-chloro 2, 3-epoxypropane	00106 89-8
chloroform	00067 66 3
1-(4-chlorophenyl) 3, 3-dimethyl triazene	07203 90-9
chloroprene	00126 99 8
*dibenz (a h) anthracene	00053 70-3
di-n butyl phthalate	00084 74 2
3 3' -dichlorobenzidine	00091-94-1
*3 3' dichlorobenzidine salts	Class 08 8
*1 2 -dichloroethane	00107 06-2
1 2 3 4 diepoxybutane	00298 18-0
4 dimethylaminoazobenzene	00060 11-7
dimethylhydrazines	Class 06 2
*4 6 -dinitro-o cresol	00534 52-1
*2 4 -dinitrophenol	00051 28-5
*2 4 dinitrotoluene	00121-14 2
*di-n-octyl phthalate	00117 84 0
2 3 -epoxy 1 propanol	00765 34-4
ethylene dibromide	00106 93-4
ethyleneimine	00151 56-4
*ethylene thiourea	00096 45-7
*bis (2-ethylhexyl 1) phthalate	00117-81-7
hexachlorobenzene (HCB)	00118 74 1

es new critical material

Organic Materials (continued)

hexachlorobutadiene (HCBD)	00087 68 3
hexachlorocyclohexane	00608 73-1
hexachlorocyclopentadiene	00077-47-4
*hexachloroethane	00067 72 1
hydrazobenzene	00122 66 7
hydroquinone	00123 31 9
n (2 hydroxyethyl) ethyleneimine	01072 52 2
lactonitrile	00078 97 7
methylene bis (2 chloroaniline)	00101 14 4
1 2 (methylenedioxy) 4 propenyl benzene	00120 58 1
methyl hydrazine	00060 34 4
*1 methyl naphthalene	00090-12-0
1 naphthylamine	00134 32 7
2 naphthylamine	00091 59 8
4 nitrobiphenyl	00092 93 3
n nitroso diethylamine	00055 18 5
n nitroso dimethylamine	00062-75-9
pentachloronitrobenzene	00082 68 8
pentachlorophenol	00087 86-5

peroxyacetic acid	00079-21-0
polybrominated biphenyls (PBB)	Class 07 8
polychlorinated biphenyls (PCB)	Class 07 9
1,3-propane sultone	01120 71-4
β-propiolactone	00057 57 8
propyleneimine	00075 55 8
semicarbazide	00057 56 7
styrene	00100 42 5
tetrachloroethylene (perchloroethylene)	00127 18 4
thiourea	00062 56 6
triaryl phosphate esters	Class 08 4
*1,1 2 trichloroethane	00079 00-5
trichloroethylene	00079 01 6
trichlorophenols	Class 07-6
tris (dibromopropyl) phosphate	00126 72-7

III Pesticides (To be reported only by manufacturers and formulators)

	Parameter Number
aldicarb	00116 06 3
aldrin	00309 00 2
4 aminopyridine	00504 24 5
*anilazine	00101 05 3
antimycin A	01397 94 0
azinphos ethyl	02642 71 9
azinphos methyl	00086 50 0
barban	00101 27 9
bendiocarb	22781 23 3
benomyl	17804 35 2
*bromoxynil	01689 84 5
captan	00133 06 2
carbaryl	00063 25 2
carbofuran	01563 66 2
carbophenothion	00786 19 6
chlordane	00057 74 9
chlordecone	00143 50 0
chlorfenvinphos	00470 90 6
*chlorobenzilate	00510 15 6
chlorpyrifos	02921 88 2
clonitralid	01420 04 8
coumaphos	00056 72 4
crotoxyphos	07700 17-6
cycloheximide	00066 81 9
DDT	00050 29 3
demeton	08065 48-3
diallate	02303-16-4
diazinon	00333-41-5
dibromochloropropane (DBCP)	00096 12-8

	Parameter Number
dichlone	00117-80 6
dichlorvos	00062 73-7
dicrotophos	00141-66 2
dieldrin	00060-57-1
dimethoate	00060 51 5
dinocap	39300 45-3
dinoseb	00088 85-7
dioxathion	00078 34-2
disulfoton	00298 04 4
endosulfan	00115 29-7
endrin	00072-20-8
EPN	02104 64-5
ethion	00563 12 2
fensulfothion	00115 90-2
fenthion	00055 38 9
fluchloralin	33245 39 5
heptachlor	00076-44-8
*heptachlor epoxide	01024 57-3
leptophos	21609-90-5
malathion	00121-75 5
methomyl	16752-77-5
methoxychlor	00072 43-5
methyl mercaptan	00074 93-1
methyl parathion	00298-00-0
mevinphos	07786 34-7
mexacarbate	00315 18-4
mirex	02385-85-5
monocrotophos	06923 22-4
naled	00300-76-5
nicotine	00054-11-5

	Parameter Number
oxydemeton methyl	00301-12 2
paraquat	01910-42 5
parathion	00056 38 2
phorate	00298 02 2
phosazetim	04104-14-7
phosmet	00732 11-6
phosphamidon	13171 21 6
rotenone	00083 79 4
silvex propylene glycolbutyl ether ester	02317 24-0
sodium fluoroacetate	00062 74 8
strychnine	00057-24 9
sulfotepp	03689-24 5
TDE	00072 54 8
TEPP	00107-49 3
terbufos	13071 79-9
thiram	00137-26 8
toxaphene	08001 35 2
trichlorfon	00052-68-6
trichlorophenoxyacetic acid (2 4,5-T)	00093-76-5
trifluralin	01582-09-8
ziram	00137-30-4

reviews the final assessments by July 1. After Committee approval, the CMR is final typed, checked for accuracy and forwarded to the DNR Director for approval. The approved CMR is published on October 1 in the Wastewater Reporting Booklet. New chemicals added to the list need be reported only after a one year grace period as required by the enabling legislation.

Should industry or any other group have data which refutes the placement of a chemical on the CMR, a formal appeal of that decision may be made. The appeal is made to the DNR Director and must be accompanied by adequate substantiating data and references. Data supplied will be reviewed and evaluated by the Office of Toxic Materials Control and the Critical Materials Advisory Committee. If the appeal is found to be valid, the chemical will be removed from subsequent years' CMR. If the appeal is denied, the specific reasons for the denial will be given.

The purpose of the CMR is to develop and maintain a list of chemicals of high environmental concern from a water oriented point of view. Presently, inhalation data is given only minor consideration in the hazard assessment process since the authority for the CMR is based on water related legislation. The goal of the overall CMR program is to provide information on the use and discharge of toxic substances which can be utilized to prevent and control pollution of the aquatic environment by these substances.

It is necessary to reach a reasonable compromise between the number of compounds included in the Register and the impact on people reporting under the law. Careful consideration must be given to future use of these data to prevent unnecessary data collection and to assure that the data can be adequately compiled and utilized. The CMR was developed for a specific purpose, thus it is not applicable to all situations where lists of toxic or hazardous chemicals are needed. No attempt has been made to include all chemicals on the CMR which may be toxic or hazardous under some conditions. Such a list would be very lengthy and it is doubtful that it would ever be complete.

Other enforcement tools are available to control toxic substances not covered by the CMR program. These tools include provisions of Act 245, P.A. 1929, as amended (Water Act); Act 348, P.A. 1965 (Air Act); Act 116, P.A. 1978 (Toxic Substances Control Commission Act); Act 641, P.A. 1978 (Solid Waste Act); and Act 64, P.A. 1979 (Hazardous Waste Act). The permit programs (Air, Groundwater, Surface Water) can also be used to limit the quantities of toxic substances entering the environment.

In addition to reviewing chemicals for water pollution control, the 1979 CMR assessment process was expanded to consider potential hazards from air pollutants. A spearate list, entitled the "1979 Air Priority Chemicals List", was developed which is composed of the 1979 CMR plus other selected chemicals producing adverse effects from inhalation exposure. The Air Priority Chemicals assessment process was continued in 1980 and the 1980 Air Priority Chemicals List was developed. This group of chemicals will be used to monitor usage and emission of air pollutants to the environment. The 1980 Air Priority Chemicals List and criteria and rationale used to develop the list are available from the Office of Toxic Materials Control.

There are several shortcomings inherent in this system. First, there is a lack of readily available information on the toxicity of many chemicals. Chemicals which lack sufficient information cannot be included on the CMR via the hazard assessment process. However, such compounds will be reviewed annually to obtain additional information as it is published. A second problem involves the lack of adequate chemical composition information about commercial products. This presents a difficulty in identifying those products which may contain toxic substances. It is often difficult and time-consuming to convince industry to release such information due to its proprietary nature. This makes it extremely difficult for users of commercial products to determine if these products contain chemicals on the CMR. As a result, compliance with the program is lowered.

A third problem is the lack of inventory data on chemical manufacture and use. Michigan presently lacks legislation which would require a company to report a chemical prior to its manufacture or use. This results in the inclusion of chemicals which may not be used in Michigan, making the CMR more lengthy than necessary. The provisions of the Federal Toxic Substances Control Act may make this information available to the State if confidentiality procedures do not block its disclosure.

CRITICAL MATERIALS ADVISORY COMMITTEE

Pursuant to Section 6(b) of Act 293, P.A. 1972, an advisory committee of environmental specialists is designated by the Director of the Department of Natural Resources to provide advice to the Director on the development and revision of the Critical Materials Register. The Committee also provides advice and recommendations on the development of the general program. The Committee is composed of representatives from academia, industry, state government and special interest groups. Members of the 1980 Critical Materials Advisory Committee are listed in Table 8.

The Advisory Committee concept has proven very beneficial in the development of the Critical Materials Program. The wide range of backgrounds represented on the Committee has allowed development and implementation of a program which can provide maximum information on use and discharge of toxic substances with as minimal an impact on industry as possible. The Advisory Committee concept also allows input by industrial and academic environmental specialists at all stages of development of the program. Additionally, this approach allows DNR staff to anticipate and avoid many potential problems during development and implementation of the program. These factors have also increased compliance with the program.

TABLE 8. CRITICAL MATERIALS ADVISORY COMMITTEE 1980

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OFFICE OF TOXIC MATERIALS CONTROL

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Richard Powers, Chairperson

Ralph Bednarz

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Terrance Kavanagh

SELECTION OF CHEMICALS FOR REVIEW

The 1977 Critical Materials Advisory Committee recognized the need for an extensive review of chemical compounds that were not included on previous Registers. At that time, there were an estimated 4,000,000 known chemicals. Approximately 50,000 chemicals were in common use (exluding pesticides, pharmaceuticals and food additives). Only a small subset of possible candidates could be selected for detailed consideration because of the large number of compounds in existence, the lack of a comprehensive and readily accessible data base on many chemicals, and the limited amount of time and staff. In order to review compounds of highest concern, the committee chose to limit its initial consideration to compounds or classes of compounds which had been identified in previous reviews. Compounds included in these reviews had potential adverse effects on human health or the environment, or large production volumes and consequent potential for substantial human exposure or environmental release. Eight separate source lists of this type were identified (Table 9). These lists, along with the 1976 CMR formed the basis of the "Proposed List of Hazardous Materials to be Screened for the 1977 Critical Materials Register" (Appendix 1). This combined list had approximately 400 entries which included specific compounds and classes of compounds. All of these compounds were reviewed for the 1977 Critical Materials Register.

The same procedure was used for the 1978 CMR revision. Two separate source lists (Table 10), a list of hazardous compounds compiled from information reported in the Federal Register, and a list of compounds identified by the Office of Toxic Materials Control staff as possible candidates for the 1978 CMR were used to compile the "List of Priority Chemical Sub-

Table 9. Chemical Lists Utilized for 1977 CMR Revision.

Potential Industrial Carcinogens and Mutagens, National Center for Toxicological Research. (90 chemicals)

Persistent Toxic Substances, International Joint Commission. (57 chemicals or classes)

List of Hazardous Substances, U.S. Environmental Protection Agency. (306 chemicals)

General Agreement - Restricted Pesticide List, December, 1976, U.S. Environmental Protection Agency. (81 chemicals)

List of Priority Pollutants, U.S. Environmental Protection Agency. (129 chemicals)

Toxic Pollutant List, Prepared by Tracor, Jitco, Inc. for the U.S. Environmental Protection Agency. (226 chemicals)

List of Substances of Concern, State of New York, Department of Environmental Conservation. (135 chemicals or classes)

OSHA Standards for Carcinogens, Occupation Safety and Health Administration. (14 chemicals)

Table 10. Chemical Lists Utilized for 1978 CMR Revision

TSCA Preliminary List, U.S. Environmental Protection Agency. (300 compounds or classes of compounds)

Preliminary Possible Pollution List, U.S. Environmental Protection Agency, Region V. (38 specific chemicals)

Table 11. Chemical Lists Utilized for 1979 CMR Revision

List of Chemical Contaminants in the Great Lakes; Table I & II. International Joint Commission, Great Lakes Water Quality Board Status Report, Appendix E. (50 chemicals)

Scoring of Organic Air Pollutants. Prepared by MITRE Corporation for the U.S. Environmental Protection Agency. EPA-450/3-77-00814. (637 chemicals)

Preliminary List of Chemicals Submitted for Air Pollution Exposure Studies. U.S. Environmental Protection Agency. (40 chemicals)

List of Chemicals with Time Weighted Average Exposure Limits for Occupational Exposure in the Workplace. Occupational Safety and Health Administration. (360 chemicals and classes) stances for Further Evaluation by the 1978 CMR Advisory Committee" (Appendix 2). Approximately 350 compounds or classes of compounds were included on this list. A total of 200 compounds from this list were evaluated for the 1978 CMR. In addition, the 218 compounds or classes of compounds on the 1977 CMR were re-evaluated to obtain additional information required for the hazard assessment scoring procedure.

The Critical Materials Advisory Committee evaluated a total of 289 compounds and classes of compounds for the 1979 CMR. These included the 190 compounds and classes of compounds on the 1978 CMR and 99 additional chemicals which were selected as possible candidates for the 1979 CMR (Appendix 3). Four separate source lists (Table 11) and a list of compounds selected by the Office of Toxic Materials Control staff for further evaluation were used to compile this list of CMR candidates.

The Advisory Committee selected 259 chemicals for the "List of Priority Chemical Substances for Further Evaluation by the 1980 CMR Advisory Committee" (Appendix 4). Major emphasis for the 1980 CMR revision was placed on chemicals recognized as carcinogens. Chemicals chosen for this list included 103 compounds selected from the chemicals evaluated by the International Agency for Research on Cancer and 60 compounds selected from the chemicals tested by the National Cancer Institute. Additionally, 48 chemicals designated by the staff of the Office of Toxic Materials Control as potential hazardous substances and 48 compounds selected for inhalation toxicity concerns were included on the list. A total of 223 compounds from this list were evaluated for the 1980 CMR.

Over 2,000 chemical compounds or classes of compounds have been reviewed, and of those approximately 750 have been hazard assessed for possible inclusion on the CMR.

CHEMICAL EVALUATION PROCEDURE

Chemical evaluations for the Critical Materials Register consist of literature searches on the physical, chemical, and toxicological properties of those chemicals selected for review from the various lists of priority chemicals noted in the preceding section or chemicals which pose potential problems in Michigan.

The procedure begins with the assignment of a literature researcher. The chemical is identified by the "most commonly used" name and the International Union of Pure and Applied Chemists (IUPAC) name. The chemical Abstract Service number is also determined. The most commonly used in-house references (Table 11) are used to define physical characteristics and develop an overview of toxicity and other adverse effects. From this point, the remaining office references (i.e. collected journal articles, texts, etc.) are reviewed. The various sections of the State of Michigan, Michigan State University, and the University of Michigan libraries dealing with chemicals and chemical toxicants are used to complete the literature summary. Chemical Abstracts, Pesticide Abstracts, International Agency for Research on Cancer Monographs, National Cancer Institute reports, NIOSH Criteria Documents, U.S. Environmental Protection Agency criteria reports, etc., are reviewed. Various computer searches such as Pollution Abstracts, Toxline, Medline, etc., available through Michigan State University are also used.

Table 12. List of Office References Most Commonly Used for Chemical Evaluations

Brown, A. W. A., Ecology of Pesticides. John Wiley & Sons. New York, New York. 1978.

Dawson, G. W., *et al.*, Control of Spillage of Hazardous Polluting Substances. Battelle Institute Federal Water Quality Administration. Richland, WA. 1970.

Dawson, G. W., *et al.*, Determination of Harmful Quantities and Rates of Penalty for Hazardous Substances. Volume III. Environmental Protection Agency, Washington, DC. 1974.

Fairchild, E. J., *et al.*, Registry of Toxic Effects of Chemical Substances (RTECS). Volumes I & II. NIOSH. Cincinnati, OH. 1977.

Gleason, M. N., *et al.*, Clinical Toxicology of Commercial Products. 4th Edition. Williams and Wilkins Company. Baltimore, MD. 1976.

Guenzi, W. D., ed. Pesticides in Soil and Water. Soil Science Society of America, Inc. Madison, WI. 1974.

Hilton, J. L., *et al.*. Herbicide Handbook. 3rd Edition. Weed Society of America. Champaign, IL. 1974.

Hawley, G. G., The Condensed Chemical Dictionary. 9th Edition. Van Nostrand Reinhold Company. New York, NY. 1977.

Key, M. M., *et al.*, Occupational Diseases, rev. ed. NIOSH. Washington, DC. 1977.

Little, A. D., Water Quality Criteria Data Book. Volume 1, "Organic Chemical Pollution of Freshwater". Environmental Protection Agency. Cambridge, MA. 1970.

Matsumura, F., Toxicology of Insecticides. Plenum Press. New York, NY 1976.

McKee, J. E. and Wolf, H. W., Water Quality Criteria. 2nd Edition. California State Water Resources Control Board. U.S. Department of Health, Education and Welfare. 1963.

Menzie, C. M., Metabolism of Pesticides. United States Department of the Interior, Fish and Wildlife Service. Bureau of Sport Fisheries and Wildlife. Special Scientific Report No. 127. Washington, DC. 1969.

Sax, N. I., Dangerous Properties of Industrial Materials. 4th Edition, Van Nostrand Reinhold Company. New York, NY. 1975.

Shepard, H. H., Pesticide Dictionary. Meister Publishing Company. Willoughby, OH. 1977.

Verschueren, K. Handbook of Environmental Data on Organic Chemicals. Van Nostrand Reinhold Company. New York, NY. 1977.

Windholz, M., *et al.* The Merck Index. 9th Edition. Merck and Company, Inc. Rahway, NJ. 1976.

Wiswesser, W. J., ed. Pesticide Index. 5th Edition. Entomological Society of America. College Park, MD. 1976.

Literature researchers record all pertinent data on the chemicals and obtain copies of the original articles on carcinogenicity, teratogenicity, mutagenicity, or chronic adverse effects. Articles are also obtained on other detailed information pertinent to an adequate chemical evaluation.

The completed evaluation includes the best available chemical and toxicological information with this information properly referenced. The evaluation is then reviewed for accuracy, references, and toxicity data.

This is a summary of the evaluation process. The complete procedure is available from the Office of Toxic Materials Control.

HAZARD ASSESSMENT PROCESS

The hazard assessment process, is a priority ranking-point assignment system, used to evaluate compounds for possible inclusion on the CMR. This system is summarized on the 1980 CMR Hazard Assessment Sheet (Table 13). The goal of the 1978 and subsequent 1979 revisions was to increase the objectivity of the hazard assessment process to better balance the degree of emphasis placed on each factor considered. Factors of environmental concern for potentially deleterious substances are separated into seven specific areas: 1) acute toxicity, 2) carcinogenicity, 3) hereditary mutagenicity, 4) teratogenicity, 5) persistence, 6) bioaccumulation, and 7) other adverse effects (including subacute and chronic effects to terrestrial and aquatic life, phytotoxicity and aesthetics). Adverse effects of metabolites or degradation products are evaluated as properties of the parent chemical. Should these metabolites or degradation products meet the criteria for placement on the register, the parent compound is included on the CMR. Criteria and rationale for each factor are included in the following section.

Each category within the seven individual factors has been assigned a point value commensurate with its level of environmental concern in keeping with the overall objectives of the program. A score of seven points in one factor or a cumulative score of seven or more points in several factors will include a chemical on the CMR. The scoring factors can be adjusted to reflect changing priorities or objectives, and to control the final composition of the list. The factors which potentially have the most severe adverse impacts on the environment and human health (acute toxicity, carcinogenicity, hereditary mutagenciity, teratogenicity, bioaccumula-

Table 13. 1980 Critical Materials Register Hazard Assessment Sheet

COMMON CHEMICAL NAME ____________________

CHEMICAL ABSTRACT NAME ____________________

TOTAL SCORE __________

CHEMICAL ABSTRACT NUMBER ☐☐☐☐☐-☐☐-☐

SCORE

I. ACUTE TOXICITY ______

SCORE	ORAL LD50 MG/KG	DERMAL LD50 MG/KG	AQUATIC 96-HOUR LC50 MG/L
7	< 5	< 5	< 1
3	5-50	5-200	1-10
2	> 50-500	> 200-500	> 10-100
1	> 500-5000	> 500-5000	> 100-1000
0	> 5000	> 5000	> 1000
•	INSUFFICIENT INFORMATION		

II. CARCINOGENICITY ______

SCORE	CATEGORY
7	HUMAN POSITIVE POTENTIAL HUMAN ANIMAL POSITIVE
3	POTENTIAL ANIMAL
2	CARCINOGENIC BY A ROUTE OTHER THAN ORAL OR DERMAL STRONGLY SUSPECT CARCINOGEN BY ACCEPTED MUTAGENICITY SCREENING TESTS
1	SUSPECT CARCINOGEN BY ACCEPTED MUTAGENICITY SCREENING TESTS
0	NOT CARCINOGENIC
•	INSUFFICIENT INFORMATION

III. HEREDITARY MUTAGENICITY ______

SCORE	CATEGORY
7	CONFIRMED
4	POTENTIAL (MULTICELLULAR ORGANISMS)
2	POTENTIAL (MICRO-ORGANISMS)
0	NOT A HEREDITARY MUTAGEN
•	INSUFFICIENT INFORMATION

IV. TERATOGENICITY ______

SCORE	CATEGORY
7	CONFIRMED
3	POTENTIAL
0	NOT TERATOGENIC
•	INSUFFICIENT INFORMATION

V. PERSISTENCE ______

SCORE	CATEGORY	T½ IN WEEKS (SOIL OR WATER)
4	VERY PERSISTENT	> 52
3	PERSISTENT	40 - 52
2	SLOWLY DEGRADABLE	27 - 39
1	MODERATELY DEGRADABLE	14 - 26
0	READILY DEGRADABLE	0 - 13
•	INSUFFICIENT INFORMATION	

VI. BIOACCUMULATION ______

SCORE	BIOACCUMULATION	LOG P
7	≥ 4000	≥ 6.00
3	1000 - 3999	5.00 - 5.99
2	700 - 999	4.50 - 4.99
1	300 - 699	4.00 - 4.49
0	< 300	< 4.00
•	INSUFFICIENT INFORMATION	

VII. OTHER ADVERSE EFFECTS ______

A. TERRESTRIAL AND AQUATIC

SCORE	CATEGORY	
	TERRESTRIAL	AQUATIC (MG/L)
7	IRREVERSIBLE EFFECTS, VERY LOW DOSE	< 0.1
3	IRREVERSIBLE EFFECTS	0.1 - 1.0
2	REVERSIBLE EFFECTS	> 1 - 10
1	ADVERSE EFFECTS BY ROUTE OTHER THAN ORAL, DERMAL, OR AQUATIC	> 10 - 100
0	NO DETECTABLE ADVERSE EFFECTS	> 100
•	INSUFFICIENT INFORMATION	

B. PLANT

SCORE	WATER (MG/L)
3	< 0.5
2	0.5 - 5
1	> 5 - 50
0	> 50
•	INSUFFICIENT INFORMATION

C. AESTHETICS

SCORE	ESTIMATED THRESHOLD LEVEL IN WATER (MG/L) TAINTING OF FISH AND/OR TASTE & ODOR	FOAMING PROPERTIES AND/OR PRODUCES FLOATING FILM AND/OR IMPARTS [illegible] COLOR CHANGE TO WATER
1	≤ 0.001	YES
0	> 0.001	NO
•	INSUFFICIENT INFORMATION	

tion and low dose adverse effects) may receive a maximum score of seven. Those factors which can receive a score of seven represent a very high level of concern and are restrictively defined in the Criteria and Rationale. Other factors which are of relatively lower concern receive correspondingly lower point values and are less restrictively defined in the criteria. Persistence is of high concern since, through longer exposure, it may increase the impact of other factors. Therefore, it receives a higher rating (number of points) than might seem justified at first. Aesthetic effects may have significant adverse impacts on the value and usefulness of aquatic systems. However, aesthetics have been scored at a lower level since their effects are of lower concern than the more critical biological effects. Phytotoxicity receives a lower rating primarily due to a lack of consistent research methodologies and damage measurements.

The actual process of scoring the chemical on the Hazard Assessment Sheet must be carefully and accurately conducted to insure the integrity of the program. Each factor in the Hazard Assessment Process is scored for all the chemical substances reviewed. All available data must be fully evaluated to determine their validity, and the proper scoring factor and category. Often, the original research publications must be obtained before a decision can be made. Staff of the DNR or members of the Advisory Committee may then make decisions on the adequacy of the testing methods, statistical analyses, and data interpretation. Experience has shown that caution must be excercised when material from summary papers, second hand references to the work of others, or references such as the Registry of Toxic Effects of Chemical Substances are used. It appears that the rate of error or misinterpretation of data in these types of publications is quite high. Therefore, it is advisable to obtain copies of the original publications whenever possible and use those data to conduct the hazard assessment.

HAZARD ASSESSMENT CRITERIA AND RATIONALE

ACUTE TOXICITY

CRITERION:

SCORE		ORAL LD50	DERMAL LD50	AQUATIC 96 HR LC50
7	Extremely Toxic	< 5 mg/kg	< 5 mg/kg	< 1 mg/l
3	Highly Toxic	5-50 mg/kg	5-200 mg/kg	1-10 mg/l
2	Moderately Toxic	> 50-500 mg/kg	> 200-500 mg/kg	> 10-100 mg/l
1	Slightly Toxic	> 0.5-5 g/kg	> 0.5-5 g/kg	> 100-1000 mg/l
0	Relatively Nontoxic	> 5 g/kg	> 5 g/kg	> 1000 mg/l
*	Insufficient information			

RATIONALE:

Classification is based upon generally accepted terminology found in the available literature on acute toxicity. The critical levels describing "highly toxic" for oral, dermal, and aquatic LC50s are adapted from Battelle Memorial Institute, National Academy of Sciences, State of California List of Toxic Substances, Federal Water Pollution Control Agency, Pesticides-Title 40, Department of Transportation Title 49, Consumer Product Safety Commission, and the Federal Hazardous Substances labeling Act Title 15 classifications (EPA, 1978), as well as systems presented by Hodge and Sterner (1949). Levels of "moderate", "slightly" and "relatively nontoxic" are adapted from the National Academy of Sciences (EPA, 1975), Hodge and Sterner (1949) and Gleason, *et al.* (1977).

Data available for each category for each type of exposure (*i.e.* oral, dermal, aquatic) are scored independently. The score assigned to the acute toxicity factor is the highest score given to any individual category. For example, a chemical substance which has an oral LD50 of 5-50 mg/kg, a dermal LD50 of 200-500 mg/kg, and an aquatic 96 hr LC50 of less than 1 mg/l is assigned a score of seven based on the extreme aquatic toxicity.

REFERENCES:

Cassarett, L. J. and Doull, J. (eds.) 1975. Toxicology, The Basic Science of Poisons. Macmillan Publishing Co., Inc. New York, New York. 768 pp.

Gleason, M. N.; Gosselin, R. E.; Hodge, H. C.; and Smith, P. R. 1977. Clinical Toxicology of Commercial Products, 4th Edition. Williams and Wilkins Company. Baltimore, MD.

Hodge, H. C. and Sterner, S. H. 1949. Tabulation of toxicity classes. AIHA Quarterly. *10*:93-96.

U.S. Environmental Protection Agency. 1975. A Summary of Hazardous Substance Classification Systems. Solid Waste Management Series (SW-171) EPA/530.

U.S. Environmental Protection Agency. 1978. Initial Report of the TSCA Interagency Testing Committee to the Administrator. EPA 560-10-78/001.

CARCINOGENICITY

CRITERION:

SCORE	CATEGORY
7	The chemical has been demonstrated to be a human positive, potential human , or animal positive carcinogen (defined below) by the oral or dermal route of exposure based on data reported by the International Agency for Research on Cancer (IARC), National Cancer Institute (NCI), or National Institute for Occupational Safety and Health (NIOSH).
3	The chemical has been demonstrated to be a potential animal carcinogen (defined below) by the oral or dermal route of exposure.
2	The chemical has been demonstrated to be an animal positive or potential animal carcinogen by any route other than oral or dermal; or has been demonstrated by accepted mutagenicity screening tests or accepted cell transformation studies to be a strongly suspect carcinogen (defined below).
1	The chemical has been demonstrated by accepted mutagenicity tests or accepted cell transformation studies to be a suspect carcinogen (defined below).
0	The chemical has been tested by the above systems and has not been demonstrated to cause cancer or to be a suspect carcinogen.
*	Insufficient information

RATIONALE:

Most cancers are believed to be caused by exposure to extrinsic factors, among which chemical agents are thought to be a major contributor. These agents must be identified, evaluated, and controlled if the incidence of cancer is to be reduced. An urgent and essential part of the Michigan Critical Materials Program is the need to protect the public and environment from chemical carcinogenic hazards and their effects. In an effort to meet this need, this carcinogenicity criterion was developed.

In addition to the standard long-term carcinogenicity test, a great deal of research is being conducted to develop rapid test methods. At present, there are two quick test systems that are of most interest, the cell transformation test and the mutagenicity test. The cell transformation test is based on the actual transformation of *in vitro* cultures of normal mammalian cells into tumor cells by brief exposure of these cell cultures to small amounts of carcinogenic agents. When the transformed cells are implanted into an animal of the species and strain from which the original normal cells were harvested they develop into malignant tumors. The basis for the mutagenicity test is the hypothesis that carcinogenesis, like mutagenesis, is due to damage of the hereditary material of the cell, DNA. The Ames test, which uses certain mutants of the bacterium *Salmonella typhimurium* is a well-known example of one of the mutagenicity tests designed to show carcinogenic potential (Bartsch, 1976; Fishbein, 1977; McCann, *et al.*, 1975).

It is essential that the procedures used to determine a chemical's carcinogenicity potential be established on the best scientific basis as practically possible. For the purpose of the Michigan Critical Materials Register, chemicals are classified as human positive, potential human, and animal positive carcinogens according to data and interpretation as reported by the IARC, NCI, or NIOSH(IARC; Sontag, *et al.*, 1976; Tomatis, 1976; USHEW). Chemicals are placed in the other carcinogenicity categories according to the best information available in the scientific literature. Chemicals can be reclassified to appropriate categories as additional data become available.

For the purpose of the Michigan Critical Materials Register, the categories of carcinogenic effects are defined as follows:

I. Human positive carcinogens are chemicals which have been demonstrated by epidemiological and/or clinical studies to cause cancer in man.

II. Potential human carcinogens are chemicals which are animal positive carcinogens and have been suggested to cause cancer in man but adequate epidemiological and/or clinical data are not available at the present time to unequivocally substantiate their carcinogenic effect in man.

III. Animal positive carcinogens are chemicals which have been demonstrated to cause cancer in at least one animal species in replicate studies or demonstrated to cause cancer in more than one animal species.

IV. Potential animal carcinogens are chemicals which have been tested in a nonreplicated study and shown to cause cancer in one animal species.

V. Strongly suspect carcinogens are chemicals which fit one of the following descriptions:

1. The chemical has been shown, using mutagenicity or cell transformation tests (with or without enzyme activation) designed to demonstrate carcinogenic potential, to be mutagenic in three groups of organisms (or cell cultures from three groups) not to include more than:

    a. one lower test organism (*i.e.* bacteria, yeast, fungi)
    b. one plant test organism (including algae)
    c. two species of mammalian test organisms
    d. one insect test organism
    e. one macroscopic aquatic or semi-aquatic organism.

2. The chemical has been shown to transform normal human cells (*e.g.* diploid fibroblasts) into tumor cells in replicated tests designed to demonstrate carcinogenic potential.

VI. Suspect carcinogens are chemicals which fit one of the following descriptions:

1. The chemical has been shown, using mutagenicity or cell transformation tests (with or without enzyme activation) designed to demonstrate carcinogenic potential, to be mutagenic in any one organism (or cell culture from any organism).

2. The chemical has been shown to transform normal human cells (*e.g.* diploid fibroblasts) into tumor cells in unreplicated tests.

REFERENCES:

Bartsch, H. 1976. Predictive value of mutagenicity tests in chemical carcinogenesis. Mutation Research, *38*:117-190.

Fishbein, L. 1977. Potential Industrial Carcinogens and Mutagens. Prepared for the Office of Toxic Substances, Environmental Protection Agency, Washington, DC. EPA 560/5-77-005.

International Agency for Research on Cancer. IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Man, Lyon, France.

McCann, J., Chico, E., Yamasaki, E., and Ames, B. N. 1975. Detection of carcinogens and mutagens in the *Salmonella*/microsome test: Assay of 300 chemicals. Proc. Natl. Acad. Sci., *72*:5135-5139.

Sontag, J. M., Norbert, P. P., Saffrotti, U. 1976. Guidelines for carcinogen bioassay in small rodents. National Cancer Institute Carcinogenesis Technical Report Series, No. 1. U.S. Department of Health, Education, and Welfare Publication No. (NIH)76-801.

Tomatis, L. 1976. The IARC program on the evaluation of carcinogenic risk of chemicals to man. Ann. N. Y. Acd. Sci., *271*:396-409.

U.S. Department of Health, Education and Welfare. Bioassay of chemical substances for possible carcinogenicity. National Cancer Institute, Carcinogenesis Technical Report Series.

HEREDITARY MUTAGEN

CRITERION:

SCORE	CATEGORY
7	Confirmed hereditary mutagen
4	Potential hereditary mutagen in multicellular organisms
2	Potential hereditary mutagen in micro-organisms
0	Not demonstrated to be a hereditary mutagen
*	Insufficient information

RATIONALE:

On a theoretical basis, mutagens can produce significant effects on the long-term survival of any species. In spite of this significant potential impact, effects due to mutagenic substances in nature might not be discernible for a long time (deSerres and Sheridan, 1973).

Most tests for mutagenicity have been designed to maximize their predictive value for carcinogenicity. The present criterion has been selected to emphasize mutagenic effects. Such mutagens represent a high level of environmental and human health concern and should therefore be included in the Critical Materials Register (Canadian Ministry of Health and Welfare, 1975).

For the purpose of the Michigan Critical Materials Register, the classification of Hereditary Mutagens to specific categories is defined below:

> To be a confirmed hereditary mutagen, a chemical must produce a statistically significant dose related mutagenic effect in test microorganisms without the use of metabolic activators (*i.e.* rodent liver fractions, *etc.*) and in a complex multicellular animal (*i.e.* insect, rodent, *etc.*) with mutations inheritable in subsequent generations of the test organisms.
>
> To be a potential hereditary mutagen in a multicellular organism, a chemical must produce a statistically significant dose related mutation in a complex multicellular organism (*i.e.* plants, insects, rodents, *etc.*) with mutations inheritable in subsequent generations of the test organism.
>
> To be a potential hereditary mutagen in microorganisms a chemical must produce a statistically significant dose related mutation in exposed test microorganisms with mutations inheritable in subsequent generations.
>
> A chemical is not considered to be a hereditary mutagen if it has been adequately tested in several appropriate animal species with negative findings.

REFERENCES:

Canadian Ministry of Health and Welfare 1975. The Testing of Chemicals for Carcinogenicity, Mutagenicity, and Teratogenicity. Ottawa.

deSerres, F. J., Sheridan, W. (eds.) 1973. The evaluation of chemical mutagenicity data in relation to population risk. Environmental Health Perspectives, Issue 6.

TERATOGENICITY

CRITERION:

SCORE	CATEGORY
7	Confirmed Teratogen
3	Potential Teratogen
0	Not Teratogenic
*	Insufficient information

RATIONALE:

Since terrestrial and aquatic populations are exposed to a wide variety of chemicals in the environment on a continuing or chronic basis, recognition and control of teratogens is necessary to prevent repetition of incidences such as Minimata disease and the "thalidomide disaster". A teratogen is any chemical which causes alterations in the formation of cells, tissues, and organs resulting from physiologic and biochemical changes, *i.e.* generative changes. Teratogenic change occurs during embryogenesis and may affect the function as well as the structure of developing cells, tissues, and organs (Becker, 1975; Canadian Ministry of Health and Welfare, 1975).

A chemical is classified as a confirmed teratogen if it has been shown by epidemiological evidence to be teratogenic in humans, demonstrated to be teratogenic in two animal species by the oral or dermal route of exposure (USEPA, 1978) or demonstrated in one animal species in replicate studies to be teratogenic by the oral or dermal route of exposure.

To be categorized as a potential teratogen the chemical must be teratogenic in one animal species by oral or dermal route in an unreplicated study.

A chemical is not considered to be teratogenic if it has been adequately tested in several appropriate animal species with negative findings (USEPA, 1978).

A confirmed teratogen would be placed on the CMR list automatically. The ranking system for suspect teratogens is more lenient to allow for lack of information and consideration of other concerns about the chemical. Should conflicting studies be found, review of the research procedures will be made to evaluate the adequacy of the study and validity of the results.

REFERENCES:

Becker, B. A. 1975. Teratogens. In: Toxicology-The Basic Science of Poisons. Edited by L. J. Casarett and J. Doull. MacMillan Publishing Company, Inc. New York. pp 768.

Canadian Ministry of Health & Welfare. 1975. The Testing of Chemicals for Carcinogenicity, Mutagenicity, Teratogenicity. Ottawa.

U.S. Environmental Protection Agency. 1978. Initial Report of the TSCA Interagency Testing Committee to the Administrator. EPA 560-10-78/001.

PERSISTENCE

CRITERION:

SCORE	CATEGORY	t 1/2 in weeks (soil or water)
4	Very persistent	> 52
3	Persistent	40 - 52
2	Slowly degradable	27 - 39
1	Moderately degradable	14 - 26
0	Readily degradable	0 - 13
*	Insufficient information	

RATIONALE:

A major factor for assessing the potential hazard of an environmental contaminant is consideration of its environmental persistence. Many synthetic compounds are highly resistant to natural degradation processes (*i.e.* biodegradation, photochemical degradation, chemical degradation) and may persist and accumulate in the environment. Continuous exposures to some substances, even at low concentrations, may result in chronic toxic effects on organisms and cumulative effects on populations. In addition, the longer a substance persists, the greater the opportunity for it to bioaccumulate to toxic levels in organisms. Of equal importance, persistent substances also have the potential for wider dispersal in the environment.

Several techniques for studying persistence and degradation of chemical substances in the environment are reported in the literature (Draggan and Giddings, 1978; Howard, *et al.*, 1975; U.S.EPA, 1979; U.S.EPA, 1978; U.S.EPA, 1975; Witherspoon, *et al.*, 1976). The design of experimental procedures for environmental persistence testing is often made on an individual chemical basis and is extremely variable. In contrast to many toxicity testing methods, techniques for studying the fate of chemicals in the environment are not standardized and interpretation of test results frequently varies. This makes it difficult to compare persistence data between chemicals.

Due to the lack of standardization among test protocols, only data obtained from test systems designed to closely simulate the natural soil or water environment are used for the persistence hazard assessment. Test systems are evaluated by DNR staff and the Critical Materials Advisory Committee. Data in the form of the half-life (t 1/2) of the chemicals in soil or water are used in order to allow for comparison between chemicals.

Time ranges for each category of persistence were selected based on data for pesticides. The very persistent category (t 1/2 > 52 weeks) includes many of the chlorinated hydrocarbon insecticides (*e.g.* DDT, aldrin, lindane) while the readily degradable category (t 1/2 = 0-13 weeks) includes many of the organophosphorus insecticides (*e.g.* dichlorvos, disulfoton, malathion) (Brown, 1978). It must be emphasized that the environmental persistence criterion was developed on information currently available. The criterion will be modified as new information and testing methodologies become available.

REFERENCES:

Brown, A. W. A. 1978. Ecology of Pesticides. John Wiley & Sons, New York, New York. 525 pp.

Draggan, S. and Giddings, J. M. 1978. Testing toxic substances for protection of the environment. The Science of the Total Environment. *9*:63-74.

Howard, P. H.; Saxena, J.; Durkin, P. R.; and Ou, L. T. 1975. Review and evaluation of available techniques for determining persistence and routes of degradation of chemical substances in the environment. EPA-560/5-75-006.

U.S. Environmental Protection Agency. 1979. Toxic substances control act premanufacture testing of new chemical substances. Guidance for premanufacture testing: Discussion of policy issues, alternative approaches, and test methods. Federal Register. *44*(53):16240-16290.

U.S. Environmental Protection Agency. 1978. Preliminary draft guidance for premanufacture notification, chemical fate. Chemical Regulation Reporter, The Bureau of National Affairs, Inc. Washington, DC. July 14, 1978. pp. 691-709.

U.S. Environmental Protection Agency. 1975. Guidelines for registering pesticides in the United States. Federal Register. *40*(123):26878-26895.

Witherspoon, J. P.; Bondietti, E. A.; Draggon, S.; Taub, F. P.; Pearson, N.; Trabalka, J. R. 1976. State-of-the-art and proposed testing for environmental transport of toxic substances:ORNL/EPA-1, Environ. Sci. Div., Pub. No. 893, Oak Ridge National Laboratory, Oak Ridge, TN.

BIOACCUMULATION

CRITERION:

	CATEGORY	
SCORE	BIOACCUMULATION	LOG P
7	≥ 4000	≥ 6.00
3	1000 - 3999	5.00 - 5.99
2	700 - 999	4.50 - 4.99
1	300 - 699	4.00 - 4.49
0	< 300	< 4.00
*	Insufficient information	

RATIONALE:

Partition coefficients for n-octanol/water are often used as a reliable measure of the tendency for an organic compound to transfer from water to organisms (lipid phase) and bioaccumulate. The n-octanol/water partition coefficient, P, is defined as the ratio of the concentration of a compound in octanol to its concentration in water. It is generally expressed as the log (base 10) of the partition coefficient, log P. The partition coefficient has proven useful as a means of predicting soil adsorption (Briggs, 1973), biological update (Kenaga, 1972; Hamelink, *et al.*, 1977), lipophilic storage (Davies, *et al.*, 1975), and biomagnification (Lu, *et al.*, 1975; Metcalf, *et al.*, 1973; Metcalf, *et al.*, 1975; Neely, *et al.*, 1974). These studies have shown a direct relationship between log P values and log bioconcentration factors for organic compounds.

Highly bioaccumulative compounds have log P values greater than 5.0. Examples of these include DDT; DDE; 2,4,5,2',5'-PCB; 2,4,5,2',4',5'-PCB; and leptophos with log P values of 6.19, 5.69, 6.11, 6.72, and 6.31, respectively (Chiou, *et al.*, 1977). Compounds which bioaccumulate to a lesser degree, such as monochlorobenzene, tetrachloroethylene, dicapthon, and diphenyl ether have log P values of 2.18, 2.60, 3.58, and 4.20 respectively (Chiou, *et al.*, 1977; Ware, *et al.*, 1977).

Log P values greater than 6.0 must be interpreted carefully before being utilized as a bioaccumulation indicator. An increase in the log P value correlates with increased propensity for bioaccumulation for many classes of chemicals. However, for certain groups of chemicals, large log P values (*i.e.* greater than 6.0) do not correlate to an increased tendency to bioaccumulate (Tulp and Hutzinger, 1978). For example, apolar polymers (such as plastics) have computed log P values that are very large, yet they are not bioaccumulated. Squalene, an isoprenoid hydrocarbon, is excreted quantitatively in the feces of rats after an oral dosage. The compound is not absorbed from the intestine, yet its computed log P value is 15.5. Additionally, some chemicals having large log P values are readily metabolized and not bioaccumulated. An organic chemical that has a log P greater than or equal to 6.0 must have the potential to bioaccumulate before it receives a score of seven points.

An organic chemical that has a log P greater than or equal to 6.0, which has the potential to bioaccumulate, and for which no data on bioaccumulation in fish is available; or a chemical that bioaccumulates greater than or equal to 4,000 times in fish (wet weight basis) at equilibrium will receive a score of seven points for the bioaccumulation category.

A chemical that has a log P less than 6.0, which has the potential to bioaccumulate and for which no data on bioaccumulation in fish is available; or a chemical that bioaccumulates less than 4,000 times in fish (wet weight basis) at equilibrium will be scored as listed above.

REFERENCES:

Briggs, G. C. 1973. A simple relationship between soil adsorption of organic chemicals and their octanol/water partition coefficients. Proceedings of the 7th British Insecticide and Fungicide Conference.

Chiou, C. T.; Freed, V. H.; Schmedding, D. W.; and Kohnert, R. L. 1977. Partition coefficient and bioaccumulation of selected organic chemicals. Environ. Sci. Technol., *11*(5):475.

Davies, J. E.; Barquet, A.; Freed, V. H.; Hague, R.; Morgrade, C.; Sonneborn, R. E.; and Vaclavek, C. 1975. Human pesticide poisonings by a fat-soluble organophosphate insecticide. Arch. Environ. Health, *30*:608.

Hamelink, J. L. and Spacie, A. 1977. Fish and chemicals: The process of accumulation. Ann. Rev. Pharmacol. Toxicol., *17*:167-77.

Kenaga, E. E. 1972. Guidelines for environmental study of pesticides: Determination of bioaccumulation potential. Res. Rev., *44*:73.

Lu, P. Y.; Metcalf, R. L. 1975. Environmental fate and biodegradability of benzene derivatives as studied in a model aquatic ecosystem. Environ. Health Perspect., *10*:269.

Metcalf, R. L.; Kapoor, I. P.; Lu, P. Y.; Schuth, C. K.; and Sherman, P. 1973. Model ecosystem studies of the environmental fate of six organochlorine pesticides. Environ. Health Perspect., *4*:35.

Metcalf, R. L.; Sanborn, J. B.; Lu, P. Y.; and Nye, D. 1975. Laboratory model ecosystem studies of the degradation and fate of radiolabeled tri-, tetra-, and pentachlorobiphenyl compared with DDE. Arch. Environ. Contam. Toxicol., *3*:151.

Neely, W. B.; Branson, D. R.; and Blau, G. E. 1974. Partition coefficient to measure bioconcentration potential of organic chemicals in fish. Environ. Sci. Technol., *8*(13):113.

Tulp, M. Th. M. and Hutzinger, O. 1978. Some thoughts on aqueous solubilities and partition coefficients of PCB, and the mathematical correlation between bioaccumulation and physio-chemical properties. Chemosphere, *10*:849-860.

Ware, S. A. and West, W. L. 1977. Investigation of selected potential environmental contaminants: Halogenated benzenes. Final Report, Office of Toxic Substances, U.S. Environmental Protection Agency, Washington, DC 283 pp.

OTHER ADVERSE EFFECTS

The Other Adverse Effects factor is divided into three subfactors for the purpose of evaluating the available data and assigning points. Each subfactor is assigned an individual score. The score assigned to the Other Adverse Effects factor is the combined scores of the three individual subfactors. Other Adverse Effects on terrestrial animals and aquatic organisms are considered in a single subfactor to be consistent with the acute toxicity criterion. The score assigned to this subfactor is the highest score given to any individual category. For example, a chemical substance which causes irreversible effects to mammals at a very low dose and has an aquatic median effective concentration of 1 mg/l is assigned a score of seven based on the toxicity to mammals.

A. TERRESTRIAL ANIMALS AND AQUATIC ORGANISMS

1. TERRESTRIAL ANIMALS

CRITERION:

SCORE	CATEGORY
7	Produces an irreversible effect at a very low dose (*i.e.* <0.5 mg/kg) by oral or dermal routes
3	Irreversible effects during or following cessation of low level exposure by oral or dermal routes
2	Reversible effects following cessation of low level exposure by oral or dermal routes
1	Adverse effects by inhalation route
0	No detectable adverse effects
*	Insufficient information

RATIONALE:

Environmental dispersion and dilution of deleterious chemicals may present adverse biological impacts at concentrations other than those necessary to cause death of 50% of observed populations. Prolonged exposure or sublethal adverse effects must be addressed since these doses present the predominant environmental contamination circumstances. These lower dosage levels may produce reversible or irreversible effects. Reversible and irreversible effects in most cases are dose dependent. Lower level doses may produce reversible effects, whereas higher doses of the same chemical may cause irreversible effects (McRae, *et al*, 1978. Except for the extremely low dose category receiving 7 points, exact numerical exposure cut-off points have not been included in order to allow flexibility in evaluating what concentrations could realistically occur in the environment and judgement of the applicability and validity of the data reviewed. For the sake of the Critical Materials Program the following definitions apply.

Irreversible Adverse Effects (Casarett and Doull, 1975; Robbins and Angell, 1971): Continued or intermittent, oral, or dermal (including occular) exposure that results in *irreversible* impairment of anatomical, physiological, biochemical, or behavioral functions during exposure or following cessation of exposure. Examples would include but not be limited to:

Benign neoplasias

Induced autoimmunity

Embryo or fetal mortality

Hypersensitivity

Metabolic disorders (*i.e.* hyper/hypoglycemia, hypo/hyperthyroidism)

Cellular necrosis causing permanent reduction of normal system, organ, or tissue structure and/or function resulting in such disorders or damage as:

- cataracts
- glaucoma
- glomerulonephritis
- hepatic failure
- arteriosclerosis
- aplastic anemia
- retinal degeneration
- renal failure
- cirrhosis
- neuronal degeneration (demylenation)
- sterility from testicular or ovarian atrophy, such as germinal aplasia leading to aspermia or azoospermia

NOTE: Carcinogenic, mutagenic, and teratogenic effects are excluded from this criterion since they have been addressed in their individual criteria.

Reversible Adverse Effects (Casarett and Doull, 1975; Robbins and Angell, 1971): Continued or intermittent, oral, or dermal (including occular) exposure that results in *reversible* impairment of functional capacity, however, enhances the susceptibility of organisms to other deleterious environmental effects. Examples would include but not be limited to:

Cellular lipid, carbohydrate, or protein infiltration not resulting in cell death;

Enzyme or hormone inhibition, (*i.e.* antiestrogenic properties, acetylcholinesterase inhibition);

Inflammation, and cellular necrosis followed by normal structure and/or function regeneration such as possible from:

- hemolytic anemia
- bone marrow suppression
- vitamin deficiencies
- thrombocytopenia
- methemoglobinemia
- skin or eye irritation (erythema and/or edema)
- retinal hemmorhage
- renal tubular necrosis
- agranulocytosis
- cerebral edema
- narcosis
- peripheral neuropathy

NOTE: A category for adverse effects caused by inhalation has been included to give credit to research which may indicate potential adverse effects that may be derived from other environmental exposure.

Besides dosage level, evaluation of environmental toxicity data must address two additional considerations: routes and duration of exposure. The most common exposure to terrestrial environmental contaminants by the water route would be skin or eye contact and ingestion. Sublethal skin and eye contact may elicit irritation, contact sensitization, ulceration, photosensitivity, pigmentary changes, nodules, vesicles, tumors, and a potential for absorption leading to systemic toxicity (NAS, 1975).

Skin and eye damage assessments can be made with available testing methods. There are currently five types of primary skin irritation tests available. Two tests are of Haskell Laboratory design and the other three tests are procedures from federal regulations: the Federal Hazardous Substances Act and the Department of Transportation Class B poison and skin corrosion tests. The tests are designed to indicate localized reaction potential and range from minor erythema through edema to corrosive damage indicated by necrosis. Two common eye tests are available: The Haskell Eye Irritation Test and the Federal Hazardous Substances Act eye irritation tests.

Duration of exposure is the other major consideration in reviewing adverse effects data. Acute studies which signify a single exposure recorded as death or no death, have been addressed in the acute toxicity section. Other exposures may be classified as prolonged or chronic. For this assessment model, prolonged studies consist of repeated exposures to a substance which may last up to 90 days. These studies, often referred to as subacute, generally use a fraction of the dose found to produce lethality in an acute study. A prolonged study is designed to show cumulative toxic effects from relatively low level exposures. Such exposures may simulate environmental contact to toxicants from accidental spills of hazardous substances, pesticide applications, air pollution incidents, occupational exposures, or other types of incidents where effects may be graded as changes in biological parameters rather than an all or none response observed in acute studies.

Chronic studies, for this hazard assessment, consist of repeated exposure to a substance for longer than 90 days and may last the lifetime of the experimental animals. These studies are designed to simulate low level environmental exposure over the lifetime of the test organism. Results are expressed in biological effect measurements similarly to those for a prolonged study (McRae, *et al.*, 1978).

Data on lethal effects resulting from acute, prolonged and chronic exposures are scored independently. However, only the single highest score based on lethal effects will be counted in the overall hazard assessment score, unless it can be established that the causes of the acute, prolonged and chronic lethal effects differ toxicologically.

2. AQUATIC ORGANISMS

CRITERION:

SCORE	MEDIAN EFFECTIVE CONCENTRATION (EC-50)
7	< 0.1 mg/l
3	0.1 - 1 mg/l
2	> 1 - 10 mg/l
1	> 10 - 100 mg/l
0	> 100 mg/l
*	Insufficient information

RATIONALE:

In addition to basic acute toxicity tests [*i.e.* 48-hr (invertebrates), 96-hr (fish)], toxicity studies measuring effects of chemical exposure on the reproductive process and other sublethal effects (*i.e.* chronic tests) are essential to a comprehensive hazard assessment program. There are basically two types of chronic toxicity tests, partial and full. A partial chronic toxicity test is one which includes a critical portion of a test organism's life cycle while a full chronic test will minimally include one complete life cycle. Full life cycle and partial life cycle tests with fish and invertebrates have become quite common and typically provide lethality and growth results as well as effects on reproduction (*e.g.* spawning, gametogenesis, and hatching success) and other sublethal responses during the course of testing (Brungs and Mount, 1978). A description of seven standard chronic toxicity tests follows:

a. Fish Full Life Cycle Test (U.S. EPA, 1972a).

This test allows exposure from newly hatched fry through reproduction and exposure of the next generation. It provides exposure during sensitive developmental stages and assesses the growth and the reproductive processes. A common standard test organism is the fathead minnow (*Pimephales promelas*) and the test takes approximately nine months to complete.

b. Fish Critical Life Stage Exposure Test (Macek and Sleight, 1977; McKim, 1977).

This test allows exposure during a very sensitive stage of the life cycle. The test starts with exposure of the organisms during most, preferably all, of the embryonic period and exposure of fry for a period of 30 days after hatching for warm water fish with embryogenic periods ranging from 1 to 14 days, and for 60 days after hatching for fishes with longer embryogenic periods (*e.g.* salmonids). Eggs from the standard test organisms, commonly fathead minnows (*P. promelas*), rainbow trout (*Salmo gairdneri*), or bluegill (*Lepomis macrochirus*), are utilized in this test. Each test requires approximately five to ten weeks for completion.

c. Partial Life Cycle (U.S. EPA, 1972b).

This test generally parallels the Fish Critical Life Stage Exposure Test described earlier, but makes appropriate modifications in exposure conditions because of the species and also starts with juvenile fish. The most common test organism for these studies is the brook trout (*Salvelinus fontinalis*).

d. Daphnia Chronic (Biesinger and Christensen, 1972; Biesinger, 1974; Adema, 1978; Canton and Adema, 1978).

This test is a full life cycle reproductive test which utilizes the freshwater invertebrates, *Daphnia magma* and *D. pulex*. The test requires only three weeks to complete.

e. Midge Chronic (Cairns, *et al.,* 1978).

This full life cycle reproductive test utilizes a variety of species of these widely distributed genera (*e.g.* Chironomus). Benthic organisms are easy to culture and use in an extensive program for evaluating compounds of limited solubility or those that tend to accumulate in sediments.

f. Algal Toxicity Tests (U.S. EPA, 1974, U.S. EPA, 1971).

A variety of tests have been developed which utilize algae as test organisms. Although algal tests are sufficiently short that they can be considered acute tests, most are in part multigeneration reproductive tests. No single published procedure for algal toxicity testing has gained wide acceptance, but recent candidates are usually patterned after the EPA Algal Assay Procedure (Bottle Test) developed to test for algal growth potential and limiting nutrient effects.

g. *Lemna* Inhibition (U.S. EPA, 1978).

The duckweed, *Lemna minor* has been used as a test organism for assessing the effects of chemical substances on aquatic macrophytes.

Aquatic chronic toxicity data from these tests will be scored based on the median effective concentration. For the purpose of the Michigan Critical Materials Register the median effective concentration (EC-50) is defined as the concentration of a test material that causes 50 percent reduction of survival, growth, or reproduction of a test population, when statistically compared to a control population, within a chronic test period.

B. PLANT

CRITERION:

SCORE	WATER
3	< 0.5 mg/l
2	0.5 - 5 mg/l
1	> 5 - 50 mg/l
0	> 50 mg/l
*	Insufficient information

RATIONALE:

Concern for plant toxicity is partially due to the adverse impact of water contaminants. Contaminated irrigation waters may have significant deleterious effects on both commercial and domestic plant growth. While it appears no standard testing procedures for terrestrial phytotoxicity have been published, data, and testing methodologies are available in literature (McKee and Wolf, 1963).

Battelle Pacific Northwest Laboratories describe a level of plant damage by use of a "mean inhibitory limit" or ILm. This is defined as the concentration at which 50% of the biomass, cell count, or photosynthetic activity is reduced as compared with a control over a 14 day period. For the sake of this assessment process, the Battelle definition will apply. A material is categorized as phytotoxic to terrestrial plants if the "mean inhibitory limit" is $\leq$ 50 mg/l (Battelle, 1973).

For terrestrial plants, photosynthetic activity measurements are based on carbon dioxide exchange between the plant and its environment. The absolute CO_2 exchanges are calculated by the difference in CO_2 concentration in incoming and outgoing air. The air exchange rate is given as the amount of CO_2 per square area of leaf multiplied by the unit of time measured (Mudd and Kozlowski, 1975).

Guderian (1977) describes several additional methods of damage evaluation.

1. Changes in growth, yield, and plant quality
2. Effects on seed quality and reproduction
3. Degree of foliar injury

The degree of foliar injury is measured by percent of necrotic area. Injury is scaled from very slight necrosis or chlorosis to extreme damage noted as very severe necrosis or chlorosis.

Due to the variability of methodologies and lack of standard testing methods, phytotoxicity data will be reviewed for completeness, testing approach and damage as evaluated by the researcher.

C. AESTHETICS

CRITERION:

SCORE	Estimated threshold level in water(mg/l)producing tainting of fish and/or taste & odor	Foaming properties and/or produces floating film and/ or imparts major color change to water
1	≤ 0.001	Yes
0	> 0.001	No

RATIONALE:

Wastewater treatment plant discharges and industrial process waste effluent may contain organic compounds which can impart objectionable taste, odor, or color to fish and other aquatic organisms. Usually, these offending materials can cause tainting at levels lower than those recognized as causing toxic effects (U.S.EPA, 1973).

The levels indicated in the criterion represent the extreme end of the level of detectability. Compounds such as chlorophenols, which taint fish at very low concentrations or impart an undesirable taste to drinking water would be included (Lillard and Powers, 1975). Objectionable properties are difficult to quantify since these adverse conditions are subjectively determined. Scoring is therefore low to give greater weight to adverse biological effects according to the philosophy of this register.

REFERENCES:

Adema, D. M. M. 1978. *Daphnia magna* as a test animal in acute and chronic toxicity tests. Hydrobiologia. 59:125-134.

Battelle Pacific Northwest Laboratories. July 1973. Program for the Management of Hazardous Wastes. Washington.

Biesinger, K. E. 1974. Recommended bioassay procedures for *Daphnia magna* chronic tests in a flowing system. Tentative U.S. Environmental Protection Agency Procedure.

Biesinger, K. E. and Christensen, G. M. 1972. Effects of various metals on survival, growth, reproduction, and metabolism of *Daphnia magna*. J. Fish. Res. Board Can., *29*:1691-1700.

Brungs, W. A. and Mount, D. I. 1978. Introduction to a discussion of the use of aquatic toxicity tests for evaluation of the effects of toxic substances. Estimating the Hazard of Chemical Substances to Aquatic Life, ASTM STP 657. J. Cairns Jr., K. L. Dickson, and A. W. Maki, Eds., American Society for Testing and Materials. pp 15-32.

Cairns, Jr., J.; Dickson, K. L., and Maki, A. W. 1978. Estimating the Hazard of Chemical Substances to Aquatic Life. American Society of Testing and Materials, STP 657. p.214

Canton, J. H. and Adema, D. M. M. 1978. Reproducibility of short-term and reproduction toxicity experiments with *Daphnia magna* and comparison of the sensitivity of *Daphnia magna* with *Daphnia pulex* and *Daphnia cucullata* in short-term experiments. Hydrobiologia, *59*:135-140.

Casarett, L. J., and Doull, J. (eds.). 1975. Toxicology, the Basic Science of Poisons. Macmillan Publishing Co., Inc. New York, New York. 768 pp.

Guderian, R. 1977. Air Pollution: Phytotoxicity of Acidic Gases and Its Significance in Air Pollution Control. Springer-Verlag. New York.

Lillard, D. A. and Powers, J. J. 1975. Aqueous Odor Thresholds of Organic Pollutants in Industrial Effluents. Environmental Protection Agency, Environmental Monitoring Series. EPA-660/4-75-002.

Macek, K. J. and Sleight, B. H., III. 1977. Utility of toxicity tests with embryos and fry of fish in evaluating hazards associated with the chronic toxicity of chemicals to fishes. Aquatic Toxicology and Hazard Evaluation, ASTM STP 634. F. L. Mayer and J. L. Hamelink, Eds., American Society for Testing and Materials. pp. 137-146.

McKee, J. E. and Wolf, H. W. 1963. Water Quality Criteria, 2nd Edition, California State Water Resources Control Board, Sacramento.

McKim, J. M. 1977. Evaluation of tests with early life stages of fish for predicting long term toxicity. J. Fish. Res. Board Can., *34*:1148-1154.

McRae, A., Whelchel, L., and Rowland, H. (eds.). 1978. Toxic Substances Control Sourcebook. Aspen Systems Corp. Maryland. 609 pp.

Mudd, J. B. and Kozlowski, T. T. 1975. Responses of Plants to Air Pollution. Academic Press. New York.

National Academy of Sciences. 1975. Principles for Evaluating Chemicals in the Environment. Washington, DC. 454 pp.

Robbins, S. L., and Angell, M. 1971. Basic Pathology. W. B. Saunders Company, Philadelphia.

U.S. Environmental Protection Agency. 1971. Algal assay procedure: Bottle Test. National Eutrophication Research Program. Corvalis, Oregon. 82 pp.

U.S. Environmental Protection Agency. 1972a. Recommended bioassay procedure for fathead minnow, *Pimephales promelas* (Rafinesque), chronic tests. Environmental Research Laboratory. Duluth, Minnesota. 13 pp.

U.S. Environmental Protection Agency. 1972b. Recommended bioassay procedure for brook trout, *Salvelinus fontinalis* (Mitchell), Partial chronic tests. Environmental Research Laboratory. Duluth, Minnesota.

U.S. Environmental Protection Agency. 1973. Water Quality Criteria, 1972. EPA-R3-73/033.

U.S. Environmental Protection Agency. 1974. Marine algal assay procedure: Bottle Test. Eutrophication and Lake Restoration Branch. Corvalis, Oregon. 43 pp.

U.S. Environmental Protection Agency. 1978. Preliminary draft guidance for premanufacture notification, ecological effects, July 14, 1978. Chemical Regulation Reporter. July 21, 1978. pp. 669-677.

SUMMARY OF HAZARD ASSESSMENT SHEETS

The 1980 CMR contains a total of 250 chemicals or classes of chemicals (Table 14). These include inorganic and organic industrial materials; pesticides; and pharmaceuticals, food additives and natural materials. The accompanying hazard assessment summaries (Table 15) indicate the numerical scores assigned by hazard factor overview of major areas of concern and the total cumulative score for each chemical on the CMR. Hazard factors receiving asterisks had insufficient data available to adequately assign a numerical score. As additional information becomes available, numerical scores will be assigned to these factors. Priorities for further review of chemicals on the CMR and those chemicals which did not meet the criteria will be based on the number of asterisks received. Top priority will be assigned to those chemical compounds receiving the most asterisks.

Complete chemical evaluations with data on the chemical, physical, and toxicological properties of each Critical Material, as well as a list of references utilized for this hazard assessment are available upon request from the Office of Toxic Materials Control. Completed Hazard Assessment Sheets for each material reviewed for possible inclusion on the CMR are also available upon request.

Table 14. Michigan Critical Materials Register 1980

Michigan Water Resources Commission
CRITICAL MATERIALS REGISTER
Published October 1, 1980

With the exception of critical material classes (where all compounds of the material are to be reported) the parameter number assigned each Critical Material is from the Chemical Abstract Service "Registry Handbook." Additional information concerning the Critical Materials Program and the individual materials may be obtained by writing:

Critical Materials Program
Office of Toxic Materials Control
Environmental Services Division
Michigan DNR
P.O. Box 30028
Lansing, Michigan 48909

I Inorganic Materials

A. The following inorganic materials and *all their compounds* are to be reported.

	Parameter Number
antimony	Class-01-0
arsenic	Class-01-1
beryllium	Class-01-2
cadmium	Class-01-3
chromium	Class-01-5
cobalt	Class-01-6
copper	Class-01-7
cyanides	Class-01-8
hypochlorite	Class-01-4
lead	Class-01-9
lithium	Class-02-0
mercury	Class-02-1
nickel	Class-02-2
selenium	Class-02-3
silver	Class-02-4
zinc	Class-02-7

B. The following specific inorganic materials are to be reported (do not report compounds).

	Parameter Number
chloramines	Class-08-6
chlorine	07762-50-5
hydrazine	00302-01-2
hydrogen sulfide	07783-06-4

II Organic Materials

	Parameter Number
acetone cyanohydrin	00075-86-5
2-acetylaminofluorene	00053-96-3
acrolein	00107-02-8
acrylic acid	00079-10-7
acrylonitrile	00107-13-1
allyl chloride	00107-05-1
• 2-aminoanthraquinone	00117-79-3
aminoazobenzene	00060-09-3
• o-aminoazotoluene	00097-56-3
4-aminobiphenyl	00092-67-1
• 3-amino-9-ethylcarbazole	00132-32-1
• 1-amino-2-methylanthraquinone	00082-28-0
aminotriazole (amitrole)	00061-82-5
aniline	00062-53-3
• aniline hydrochloride	00142-04-1
o-anisidine	00090-04-0
• o-anisidine hydrochloride	00134-29-2
benz(a)anthracene	00056-55-3
benzena	00071-43-2
benzidine	00092-87-5
benzidine salts	Class-08-7
benzo(a)pyrene	00050-32-8
brucine	00357-57-3
carbon tetrachloride	00056-23-5
chlorinated dibenzofurans	Class-05-3
chlorinated dioxins	Class-05-4
1-chloro-2,3-epoxypropane	00106-89-8
bis(2-chloroethyl)ether	00111-44-4
chloroform	00067-66-3
bis(2-chloromethyl)ether	00542-88-1
• 3-(chloromethyl)pyridine hydrochloride	06959-48-4
1-(4-chlorophenyl)-3,3-dimethyltriazene	07203-90-9
• 4-chloro-m-phenylenediamine	05131-60-2
• 4-chloro-o-pheylenediamine	00095-83-0
chloroprene	00126-99-8
• 5-chloro-o-toluidine	00095-79-4
• p-cresidine	00120-71-8
• 2,4-diaminoanisole sulfate	39156-41-7
• 4,4'-diaminodiphenyl ether	00101-80-4
• 2,4-diaminotoluene	00095-80-7
dibenz(a,h)anthracene	00053-70-3
tris(dibromopropyl)phosphate	00126-72-7
di-n-butyl phthalate	00084-74-2
3,3'-dichlorobenzidine	00091-94-1
3,3'-dichlorobenzidine salts	Class-08-8
1,2-dichloroethane	00107-06-2
1,2 3,4-diepoxybutane	00298-18-0
• diethyl sulfate	00064-67-5
4-dimethylaminoazobenzene	00060-11-7
dimethylhydrazines	Class-06-2
4,6-dinitro-o-cresol	00534-52-1
2,4-dinitrophenol	00051-28-5
2,4-dinitrotoluene	00121-14-2
di-n-octyl phthalate	00117-84-0
• 1,4-dioxane	00123-91-1
2,3-epoxy-1-propanal	00765-34-4
ethylene dibromide	00106-93-4
ethyleneimine	00151-56-4
• ethylene oxide	00075-21-8
ethylene thiourea	00096-45-7
bis(2-ethylhexyl)phthalate	00117-81-7
• ethylmethanesulfonate	00062-50-0
• 2-(2-formylhydrazino)-4-(5-nitro-2-furyl)-thiazole	03570-75-0
hexachlorobenzene (HCB)	00118-74-1
hexachlorobutadiene	00087-68-3
hexachlorocyclohexane	00608-73-1
hexachlorocyclopentadiene	00077-47-4
hexachloroethane	00067-72-1
hydrazobenzene	00122-66-7
hydroquinone	00123-31-9
N-(2-hydroxyethyl)ethyleneimine	01072-52-2
lactonitrile	00078-97-7
• malachite green	00569-64-2

• indicates new critical material

Table 14. (cont'd.) Michigan Critical Materials Register 1980

Organic Materials (continued)

methylenebis(2 chloroaniline)	00101-14-4
• 4,4 -methylenebis(2-methylaniline)	00838-88-0
• 4,4 -methylenebis(N,N-dimethylaniline)	00101-61-1
1,2(methylenedioxy)-4-propenyl benzene	00120-58-1
methyl hydrazine	00060-34-4
1-methylnaphthalene	00090-12-0
• 2-methyl-1-nitroanthraquinone	00129-15-7
• mustard gas	00505-60-2
• 1,5-naphthalenediamine	02243-62-1
1-naphthylamine	00134-32-7
2-naphthylamine	00091-59-8
• 5-nitroacenaphthene	00602-87-9
• 5-nitro-o-anisidine	00099-59-2
4-nitrobiphenyl	00092-93-3
• nitrogen mustard	00051-75-2
• N-nitroso-n-butyl-N-(4-hydroxybutyl) amine	03817-11-6
N-nitrosodiethylamine	00055-18-5
N-nitrosodimethylamine	00062-75-9
• p-nitrosodiphenylamine	00156-10-5
• N-nitroso-N-ethylurea	00759-73-9
• N-nitroso-N-methylurea	00684-93-5
• N-nitroso-N-methylurethane	00615-53-2
• N-nitrosomethylvinylamine	04549-40-0
• N-nitrosomorpholine	00059-89-2
• N-nitroso-N-phenylhydroxylamine, ammonium salt	00135-20-6
• N-nitrososarcosine	13256-22-9
pentachloronitrobenzene	00082-68-8
pentachlorophenol	00087-86-5
peroxyacetic acid	00079-21-0
• piperonyl sulfoxide	00120-62-7
polybrominated biphenyls (PBB)	Class-07-8
polychlorinated biphenyls (PCB)	Class-07-9
1,3-propane sultone	01120-71-4
β-propiolactone	00057-57-8
• 5-propyl-1,3-benzodioxole	00094-58-6
propyleneimine	00075-55-8
semicarbazide	00057-56-7
styrene	00100-42-5
tetrachloroethylene (perchloroethylene)	00127-18-4
• thioacetamide	00062-55-5
• 4,4'-thiodianiline	00139-65-1
thiourea	00062-56-6
• o-toluidine	00095-53-4
• o-toluidine hydrochloride	00636-21-5
triaryl phosphate esters	Class-08-4
1,1,2-trichloroethane	00079-00-5
trichloroethylene	00079-01-6
trichlorophenols	Class-07-6
• 2,4,5-trimethylaniline	00137-17-7
• trimethylphosphate	00512-56-1
• xylene	01330-20-7

III Pesticides (to be reported only by manufacturers and formulators)

	Parameter Number
aldicarb	00116-06-3
aldrin	00309-00-2
4-aminopyridine	00504-24-5
anilazine	00101-05-3
antimycin A	01397-94-0
azinphos-ethyl	02642-71-9
azinphos-methyl	00086-50-0
barban	00101-27-9
bendiocarb	22781-23-3
benomyl	17804-35-2
bromoxynil	01689-84-5
• 2(p-tert-butylphenoxy)-isopropyl-2-chloroethyl sulfite	00140-57-8
• captafol	02425-06-1
captan	00133-06-2
carbaryl	00063-25-2
carbofuran	01563-66-2
carbophenothion	00786-19-6
chlordane	00057-74-9
chlordecone	00143-50-0
chlorfenvinphos	00470-90-6
chlorobenzilate	00570-15-6
chlorpyrifos	02921-88-2
clonitralid	01420-04-8
coumaphos	00056-72-4
crotoxyphos	07700-17-6
cycloheximide	00066-81-9
DDT	00050-29-3
demeton	08065-48-3
diallate	02303-16-4
diazinon	00333-41-5
dibromochloropropane (DBCP)	00096-12-8
dichlone	00117-80-6
dichlorvos	00062-73-7
dichrotophos	00141-66-2
dieldrin	00060-57-1
dimethoate	00060-51-5
dinocap	39300-45-3
dinoseb	00088-85-7
dioxathion	00078-34-2
disulfoton	00298-04-4
endosulfan	00115-29-7
endrin	00072-20-8
EPN	02104-64-5
ethion	00563-12-2
fensulfothion	00115-90-2
fenthion	00055-38-9
fluchloralin	33245-39-5
heptachlor	00076-44-8
heptachlor epoxide	01024-57-3
leptophos	21609-90-5
malathion	00121-75-5
methomyl	16752-77-5
methoxychlor	00072-43-5
methyl mercaptan	00074-93-1
methyl parathion	00298-00-0
mevinphos	07786-34-7
mexacarbate	00315-18-4
mirex	02385-85-5
monocrotophos	06923-22-4
naled	00300-76-5
nicotine	00054-11-5
• nitrofen	0153[illegible]
oxydemeton-methyl	[illegible]
paraquat	01910-42[illegible]
parathion	00056-38-2
phorate	00298-02-2
phosazetim	04104-14-7
phosmet	00732-11-6
phosphamidon	13171-21-6
rotenone	00083-79-4
silvex, propylene glycolbutyl ether ester	02317-24-0
sodium fluoroacetate	00062-74-8
strychnine	00057-24-9
• sulfallate	00095-06-7
sulfotepp	03689-24-5
TDE	00072-54-8
TEPP	00107-49-3
terbufos	13071-79-9
• tetrachlorvinphos	00961-11-5
thiram	00137-26-8
toxaphene	08001-35-2
trichlorfon	00052-68-6
trichlorophenoxyacetic acid (2,4,5-T)	00093-76-5
trifluralin	01582-09-8
ziram	00137-30-4

IV. Drugs, Food Additives, Natural Materials (to be reported only by manufacturers and formulators).

	Parameter Number
• actinomycin D	00050-76-0
• citrus red no. 2	06358-53-8
• cycasin	14901-08-7
• cyclophosphamide	00050-18-0
• diethylstilbestrol	00056-53-1
• isonicotinic acid hydrazine	00054-85-3
• lasiocarpine	00303-34-4
• mestranol	00072-33-3
• methylthiouracil	00056-04-2
• mitomycin C	00050-07-7
• monocrotaline	00315-22-0
• niridazole	00061-57-4
• nithiazide	00139-94-6
• N-[4-(5-nitro-2-furanyl)-2-thiazolyl]acetamide	00531-82-8
• phenazopyridine hydrochloride	00136-40-3
• phenesterin	03546-10-9
• phenobarbitol	00050-06-6
• phenytoin	00057-41-0
• phenytoin sodium	00630-93-3
• propylthiouracil	00051-52-5
• uracil mustard	00066-75-1

• indicates new critical material

Table 15. 1980 Critical Materials Hazard Assessment Summary

THE HAZARD ASSESSMENT PROCESS IS A PRIORITY RANKING (POINT ASSIGNMENT) SYSTEM, USED TO EVALUATE CHEMICALS FOR POSSIBLE INCLUSION ON THE CRITICAL MATERIALS REGISTER. FACTORS OF ENVIRONMENTAL CONCERN FOR POTENTIALLY DELETERIOUS SUBSTANCES ARE EVALUATED INDEPENDENTLY [illegible]: 1) ACUTE TOXICITY, 2) CARCINOGENICITY, 3) HEREDITARY MUTAGENICITY, 4) TERATOGENICITY 5) OTHER ADVERSE EFFECTS (INCLUDING SUBACUTE AND CHRONIC EFFECTS TO TERRESTRIAL AND AQUATIC LIFE, PHYTOTOXICITY AND AESTHETICS); 6) PERSISTENCE; AND 7) BIOACCUMULATION. THE HAZARD ASSESSMENT PROCESS IS BASED ON EXTENSIVE REVIEW OF THE SCIENTIFIC LITERATURE ON PHYSICAL, CHEMICAL, AND TOXICOLOGICAL PROPERTIES OF INDUSTRIAL AND AGRICULTURAL CHEMICALS. CHEMICALS ARE NUMERICALLY SCORED AS TO THEIR POTENTIAL. THOSE WHICH POSE A HIGH ENVIRONMENTAL CONCERN ARE INCLUDED IN THE CRITICAL MATERIAL REGISTER.

A COMPLETE EXPLANATION OF THE CRITICAL MATERIALS REGISTER AND THE HAZARD ASSESSMENT PROGRAM CAN BE FOUND IN THE PUBLICATION, 'CRITICAL MATERIALS REGISTER 1980'. TO OBTAIN A COPY

WRITE:
CRITICAL MATERIALS PROGRAM
MICHIGAN DEPARTMENT OF NATURAL RESOURCES
ENVIRONMENTAL SERVICES DIVISION
P. O. BOX 30028
LANSING, MICHIGAN 48909

CALL.
MDNR, OFFICE OF TOXIC MATERIALS CONTROL
(517) 374-9640

……

KEY:

ACUTE TOXICITY
TOT=TOTAL
*=INSUFFICIENT INFORMATION
ORA=ACUTE ORAL TOXICITY
DER=ACUTE DERMAL TOXICITY
AQU=ACUTE AQUATIC TOXICITY
INH=ACUTE INHALATION TOXICITY
H MUT=HEREDITARY MUTAGENICITY
TERT=TERATOGENICITY
BIOA=BIOACCUMULATION
B=BIOACCUMULATION FACTOR
P=LOG PARTITION COEFFICIENT
I=INSUFFICIENT INFORMATION

CARC=CARCINOGENICITY
HP=HUMAN POSITIVE
PH=POTENTIAL HUMAN
AP=ANIMAL POSITIVE
PA-POTENTIAL ANIMAL
SS=STRONGLY SUSPECT CARCINOGEN
SC=SUSPECT CARCINOGEN
NC=NOT CARCINOGENIC
I=INSUFFICIENT INFORMATION

PER=PERSISTENCE
S=SOIL
W=WATER
A=AIR
Q=SOIL, WATER AND AIR
T=SOIL AND WATER
N-A=NOT APPLICABLE
I=INSUFFICIENT INFORMATION
OTHER ADVERSE EFFECTS
ATE=ADVERSE TERRESTRIAL EFFECT
AQE=ADVERSE AQUATIC EFFECTS
APE=ADVERSE PLANT EFFECTS
AAE=ADVERSE AESTHETIC EFFECTS
NS=NO SCORE

********** ATTENTION **********

SOME OF THE DATA HAVE BEEN ABBREVIATED ACCORDING TO PROCEDURES GENERALLY ACCEPTED BY THE SCIENTIFIC COMMUNITY DUE TO THE COMPLEX AND HIGHLY TECHNICAL NATURE OF MUCH OF THE INFORMATION. CAREFUL INTERPRETATION OF THE DATA IS ESSENTIAL BEFORE AN ACCURATE HAZARD ASSESSMENT CAN BE MADE. INTERPRETATION OF THE INFORMATION BY INDIVIDUALS NOT EXPERIENCED WITH THIS SUBJECT COULD RESULT IN ERRONEOUS JUDGEMENTS OF THE HAZARDS ASSOCIATED WITH THIS CHEMICAL SUBSTANCE. ALL QUESTIONS ON DATA ACCURACY AND INTERPRETATION SHOULD BE DIRECTED TO THE OFFICE OF TOXIC MATERIALS CONTROL (517) 374-9640.

COMMON CHEMICAL NAME	CAS NUMBER	TOTAL SCORES	ACUTE TOXICITY					CARCN.	H.MUT	TERT	OTHER ADVERSE EFFECTS				PERS	BIOA
			TOT	ORA	DER	AQU	INH				TOTAL	ATE/AQU	APE	AAE		
Inorganic Materials																
antimony	Class010	W-15-4*	3	2	*	3	NS	*-II	*	*	03-1*	3	*	2	*	N-A	7-B
arsenic	Class011	W-20-2*	3	*	3	7	NS	7-HP	*	3	03-1*	3	2	2	*	N-A	2-B
beryllium	Class012	W-12-4*	7	2	*	7	NS	2-SS	*	*	03-2*	3	*	*	*	N-A	*-1
cadmium	Class013	W-19-3*	7	2	*	7	NS	2-SS	*	*	07-2*	*	7	*	*	N-A	3-B
chromium	Class015	W-09-3*	3	2	*	3	NS	2-SS	*	*	02-0*	1	2	2	0	N-A	*-1
cobalt	Class016	W-07-5*	2	2	*	*	NS	*-II	*	*	03-2*	3	*	*	*	N-A	*-1
copper	Class017	W-13-3*	7	3	*	7	NS	*-II	*	*	03-0*	3	*	3	0	N-A	*-1
cyanides	Class018	W-10-5*	7	7	*	7	NS	*-II	*	*	03-2*	2	3	*	*	N-A	*-1
hypochlorite	Class014	W-07-6*	7	*	*	7	NS	*-II	*	*	NS-3*	*	*	*	0	0-S	0-B
lead	Class019	W-07-4*	7	2	*	7	NS	7-AP	*	3	07-2*	7	*	*	*	N-A	*-1
lithium	Class020	W-08-5*	2	2	*	*	NS	*-II	*	3	03-2*	3	*	*	*	N-A	*-1
mercury	Class021	W-24-4*	7	3	*	7	NS	*-II	*	7	03-2*	3	*	*	*	N-A	7-B
nickel	Class022	W-19-4*	3	3	*	3	NS	2-SS	*	*	07-2*	3	7	*	*	N-A	7-B
selenium	Class023	W-19-4*	2	2	*	2	NS	7-AP	*	7	03-2*	3	*	*	*	N-A	*-1
silver	Class024	W-10-6*	7	3	*	7	NS	*-II	*	*	03-2*	3	*	*	*	N-A	*-1
zinc	Class027	W-10-4*	7	2	*	7	NS	*-II	*	*	03-1*	2	3	*	0	N-A	0-B
chloramines	Class086	W-07-8*	7	*	*	7	NS	*-II	*	*	NS-3*	*	*	*	*	*-1	*-1
chlorine	07782505	W-14-4*	7	*	*	7	NS	*-II	*	*	07-1*	7	*	*	0	N-A	0-B
hydrazine	00302012	W-11-5*	3	2	3	*	NS	7-AP	*	*	01-1*	1	*	*	0	*-1	*-1
hydrogen sulfide	07783064	W-10-6*	7	*	*	7	NS	*-II	*	*	02-1*	2	*	*	1	*-1	*-1
Organic Materials																
acetone cyanohydrin	00075865	W-09-7*	7	7	*	3	NS	*-II	*	*	02-2*	2	*	*	*	*-1	*-1
2-acetylaminofluorene	00053963	W-08-7*	1	1	*	*	NS	7-HP	*	*	NS-3*	*	*	*	*	*-1	*-1
acrolein	00107028	W-07-8*	7	3	*	*	NS	*-II	*	*	NS-3*	*	*	*	*	*-1	*-1
acrylic acid	00079107	W-07-6*	2	2	2	2	NS	*-II	*	3	02-2*	2	*	*	*	*-1	*-1
acrylonitrile	00107131	W-16-5*	3	3	*	2	NS	7-AP	*	3	03-2*	3	*	*	*	*-1	*-1
allyl chloride	00107051	W-07-6*	2	*	*	2	NS	3-PA	*	*	02-2*	2	*	*	*	*-1	*-1
2-aminoanthraquinone	00117793	W-10-7*	*	*	*	*	NS	7-AP	*	*	03-2*	3	*	*	*	*-1	*-1
aminoazobenzene	00060093	W-07-8*	*	*	*	*	NS	7-AP	*	*	NS-3*	*	*	*	*	*-1	*-1
o-aminoazotoluene	00097563	W-10-7*	*	*	*	*	NS	7-AP	*	*	03-2*	3	*	*	*	*-1	*-1
4-aminobiphenyl	00092671	W-09-7*	2	2	*	*	NS	7-HP	*	*	NS-3*	*	*	*	*	*-1	*-1
3-amino-9-ethylcarbazole	00132321	W-09-7*	2	2	*	*	NS	7-AP	*	*	NS-3*	*	*	*	*	*-1	*-1
1-amino-2-methylanthraquinone	00082280	W-10-7*	*	*	*	*	NS	7-AP	*	*	03-2*	3	*	*	*	*-1	*-1
aminotriazole (amitrol)	00061825	W-11-5*	2	1	*	2	NS	7-AP	*	*	02-2*	2	*	*	*	0-S	*-1
aniline	00062533	W-07-5*	2	2	1	2	NS	3-PA	*	*	02-1*	2	*	*	0	*-1	*-1
aniline hydrochloride	00142041	W-08-6*	3	1	*	3	NS	3-PA	*	*	02-2*	2	*	*	*	*-1	*-1
o-anisidine	00090040	W-08-7*	1	1	*	*	NS	7-AP	*	*	NS-3*	*	*	*	*	*-1	*-1
o-anisidine hydrochloride	00134292	W-07-8*	*	*	*	*	NS	7-AP	*	*	NS-3*	*	*	*	*	*-1	*-1
benz(a)anthracene	00056553	W-07-8*	*	*	*	*	NS	7-AP	*	*	NS-3*	*	*	*	*	*-1	*-1
benzene	00071432	W-11-6*	2	1	*	2	NS	7-PH	*	*	02-2*	2	*	*	*	*-1	*-1
benzidine	00092875	W-10-7*	3	2	*	3	NS	7-HP	*	*	NS-3*	*	*	*	*	*-1	*-1
benzidine salts	Class087	W-10-7*	3	2	*	3	NS	7-HP	*	*	NS-3*	*	*	*	*	*-1	*-1
benzo(a)pyrene	00050328	W-07-8*	*	*	*	*	NS	7-AP	*	*	NS-3*	*	*	*	*	*-1	*-1
brucine	00357573	W-07-7*	7	7	*	3	NS	*-II	*	*	NS-3*	*	*	*	*	*-1	0-P

COMMON CHEMICAL NAME	CAS NUMBER	TOTAL SCORES	ACUTE TOXICITY					CARCIN	H.MUT	TERT	OTHER ADVERSE EFFECTS				PERS	BIOA
			TOT	ORA	DER	AQU	INH				TOTAL	ATE/AQU	APE	AAE		
Organic Materials																
carbon tetrachloride	00056235	W-12-4*	2	1	*	2	NS	7-PH	*	*	03-1*	3	*	*	0	*-1	0-B
chlorinated dibenzofurans	Class053	H-07-8*	7	7	*	*	NS	*-II	*	*	NS-3*	*	*	*	*	*-1	*-1
chlorinated dioxins	Class054	H-33-3*	7	7	*	7	NS	1-SC	*	7	07-2*	7	*	*	*	4-S	7-B
1-chloro-2,3-epoxypropane	00106898	H-07-6*	2	2	*	*	NS	*-II	*	*	03-2*	3	*	*	*	0-W	*-1
bis(2-chloroethyl)ether	00111444	H-08-6*	2	2	2	1	NS	3-PA	*	*	03-2*	3	*	*	*	*-1	*-1
chloroform	00067663	H-11-5*	2	1	*	2	NS	7-AP	*	*	02-2*	2	*	*	*	*-1	0-B
bis(2-chloromethyl)ether	00542881	H-10-4*	2	2	2	*	NS	7-HP	*	*	01-2*	1	*	*	*	0-W	0-P
3-(chloromethyl)pyridine hydrochloride	06959484	H-09-7*	2	2	*	*	NS	7-AP	*	*	NS-3*	*	*	*	*	*-1	*-1
1-(4-chlorophenyl)-3,3-dimethyl triazene	07203909	H-07-6*	2	2	*	*	NS	2-SS	*	*	03-2*	3	*	*	*	*-1	*-1
4-chloro-m-phenylenediamine	05131602	H-07-8*	*	*	*	*	NS	7-AP	*	*	NS-3*	*	*	*	*	*-1	*-1
4-chloro-o-phenylenediamine	00095830	H-07-8*	*	*	*	*	NS	7-AP	*	*	NS-3*	*	*	*	*	*-1	*-1
chloroprene	00126998	H-13-5*	2	2	*	2	NS	1-SC	*	7	03-2*	3	*	*	*	*-1	*-1
5-chloro-o-toluidine	00095794	H-07-6*	2	2	*	*	NS	3-PA	*	*	02-2*	2	*	*	*	*-1	*-1
p-cresidine	00120718	H-08-7*	1	1	*	*	NS	7-AP	*	*	NS-3*	*	*	*	*	*-1	*-1
2,4-diaminoanisole sulfate	39156417	H-11-7*	*	*	*	*	NS	7-AP	4	*	NS-3*	*	*	*	*	*-1	*-1
4,4'-diaminodiphenyl ether	00101804	H-11-6*	1	1	*	*	NS	7-AP	*	*	03-2*	3	*	*	*	*-1	*-1
2,4-diaminotoluene	00095807	H-11-6*	2	2	*	*	NS	7-AP	*	*	02-2*	2	*	*	*	*-1	*-1
dibenz(a,h)anthracene	00053703	H-07-8*	*	*	*	*	NS	7-AP	*	*	NS-3*	*	*	*	*	*-1	*-1
tris(dibromopropyl)phosphate	00126727	H-10-7*	3	*	*	3	NS	7-AP	*	*	NS-3*	*	*	*	*	*-1	*-1
di-n-butyl phthalate	00084742	W-09-6*	7	*	*	7	NS	*-II	*	*	02-2*	2	*	*	*	*-1	0-P
3,3'-dichlorobenzidine	00091941	H-07-7*	*	*	*	*	NS	7-PH	*	*	NS-3*	*	*	*	*	*-1	0-B
3,3'dichlorobenzidine salts	Class088	H-07-7*	*	*	*	*	NS	7-PH	*	*	NS-3*	*	*	*	*	*-1	0-B
1,2-dichloroethane	00107062	H-10-6*	1	1	*	1	NS	7-AP	*	*	02-2*	2	*	*	*	*-1	*-1
1,2:3,4-diepoxybutane	00298180	H-09-7*	2	2	*	*	NS	7-AP	*	*	NS-3*	*	*	*	*	*-1	*-1
diethyl sulfate	00064675	H-08-6*	2	1	1	2	NS	2-SS	4	*	NS-3*	*	*	*	*	*-1	*-1
4-dimethylaminoazobenzene	00060117	H-09-7*	2	2	*	*	NS	7-PH	*	*	NS-3*	*	*	*	*	*-1	*-1
dimethylhydrazines	Class062	H-15-5*	3	3	*	*	NS	7-AP	*	3	02-2*	2	*	*	*	*-1	*-1
4,6-dinitro-o-cresol	00534521	W-07-8*	7	3	3	7	NS	*-II	*	*	NS-3*	*	*	*	*	*-1	*-1
2,4-dinitrophenol	00051285	H-07-6*	3	3	*	3	NS	*-II	*	*	03-1*	*	3	*	1	*-1	*-1
2,4-dinitrotoluene	00121142	H-08-6*	2	2	*	2	NS	3-PA	*	*	03-2*	3	*	*	*	*-1	*-1
di-n-octyl phthalate	00117840	H-09-7*	*	*	*	*	NS	*-II	*	*	02-2*	2	*	*	*	*-1	7-B
1,4-dioxane	00123911	H-10-6*	1	1	0	1	NS	7-AP	*	*	02-6*	2	*	*	*	*-1	*-1
2,3-epoxy-1-propanal	00765344	H-08-6*	2	*	2	*	NS	3-PA	*	*	03-2*	3	*	*	*	*-1	*-1
ethylene dibromide	00106934	H-11-6*	2	2	2	2	NS	7-AP	*	*	02-2*	2	*	*	*	*-1	*-1
ethyleneimine	00151564	H-17-4*	7	7	3	*	NS	7-PH	*	*	03-2*	3	*	*	*	0-W	0-P
ethylene oxide	00075218	H-10-2*	2	2	*	2	NS	2-SC	4	*	02-1*	2	*	*	0	0-W	0-P
ethylene thiourea	00096457	H-16-6*	*	*	*	*	NS	7-AP	*	7	02-2*	2	*	*	*	*-1	*-1
bis(2-ethylhexyl)phthalate	00117817	W-09-5*	*	*	*	*	NS	0-NC	*	*	07-2*	7	7	*	*	0-W	2-B
ethylmethanesulfonate	00062500	H-10-6*	*	*	*	*	NS	2-SC	7	*	01-2*	1	*	*	*	*-1	*-1
2-(2-formylhydrazine)-4-(5-nitro-2-furyl) thiazole	03570750	H-07-8*	*	*	*	*	NS	7-AP	*	*	NS-3*	*	*	*	*	*-1	*-1
hexachlorobenzene (HCB)	00118741	W-25-2*	1	1	*	*	NS	3-PA	*	7	03-1*	3	*	*	0	4-S	7-P
hexachlorobutadiene	00087683	H-12-5*	7	2	*	7	NS	3-PA	*	*	02-1*	2	*	*	0	*-1	*-1
hexachlorocyclohexane	00608731	H-20-5*	7	2	*	7	NS	7-AP	*	*	02-2*	2	*	*	*	4-S	*-1
hexachlorocyclopentadiene	00077474	H-11-5*	7	2	*	7	NS	*-II	*	*	02-1*	2	*	*	1	*-1	1-B
hexachloroethane	00067721	H-07-6*	1	1	*	*	NS	3-PA	*	*	03-2*	3	*	*	*	*-1	*-1

			ACUTE TOXICITY								OTHER ADVERSE EFFECTS						
COMMON CHEMICAL NAME	CAS NUMBER	TOTAL SCORES	TOT	ORA	DER	AQU	INH	CARCN.	H.MUT	TERT	TOTAL	ATE/	AQU	APE	AAE	PERS	BIOA
hydrazobenzene	00122667	W-09-7*	2	2	*	*	NS	7-AP	*	*	NS-3*	*	*	*	*	*-I	*-I
hydroquinone	00123319	W-09-7*	7	2	*	7	NS	*-II	*	*	02-2*	2	*	*	*	*-I	*-I
N-(2-hydroxyethyl)ethyleneimine	01072522	W-07-6*	2	2	2	*	NS	2-SC	*	*	03-2*	3	*	*	*	*-I	*-I
lactonitrile	00078977	W-07-7*	7	3	*	7	NS	*-II	*	*	NS-2*	*	*	*	0	*-I	*-I
malachite green	00569642	W-07-8*	7	*	*	7	NS	*-II	*	*	NS-3*	*	*	*	*	*-I	*-I
methylenebis(2-chloroaniline)	00101144	W-08-7*	1	1	*	*	NS	7-PH	*	*	NS-3*	*	*	*	*	*-I	*-I
4,4'-methylenebis(2-methylaniline)	00838880	W-11-6*	1	1	*	*	NS	7-AP	*	*	03-2*	3	*	*	*	*-I	*-I
4,4'-methylenebis(N,N-dimethylaniline)	00101611	W-08-7*	1	1	*	*	NS	7-AP	*	*	NS-3*	*	*	*	*	*-I	*-I
1,2(methylenedioxy)-4-propenyl-benzene	00120581	W-11-6*	1	1	*	*	NS	7-AP	*	*	03-2*	3	*	*	*	*-I	*-I
methyl hydrazine	00060344	W-10-5*	3	3	3	*	NS	3-PA	*	*	01-2*	1	*	*	*	*-I	*-I
1-methylnaphthalene	00090120	W-07-7*	7	*	*	7	NS	*-II	*	*	NS-2*	*	*	*	0	*-I	*-I
2-methyl-1-nitroanthraquinone	00129157	W-07-8*	*	*	*	*	NS	7-AP	*	*	NS-3*	*	*	*	*	*-I	*-I
mustard gas	00505602	W-08-6*	3	*	3	*	NS	2-SS	*	*	03-2*	3	*	*	*	*-I	*-I
1,5-naphthalenediamine	02243621	W-07-8*	*	*	*	*	NS	7-AP	*	*	NS-3*	*	*	*	*	*-I	*-I
1-naphthylamine	00134327	W-10-7*	3	1	*	3	NS	7-PH	*	*	NS-3*	*	*	*	*	*-I	*-I
2-naphthylamine	00091598	W-10-7*	3	1	*	3	NS	7-HP	*	*	NS-3*	*	*	*	*	*-I	*-I
5-nitroacenaphthene	00602879	W-07-8*	*	*	*	*	NS	7-AP	*	*	NS-3*	*	*	*	*	*-I	*-I
5-nitro-o-anisidine	00099592	W-08-7*	1	1	*	*	NS	7-AP	*	*	NS-3*	*	*	*	*	*-I	*-I
4-nitrobiphenyl	00092933	W-08-7*	1	1	*	*	NS	7-PH	*	*	NS-3*	*	*	*	*	*-I	*-I
nitrogen mustard	00051752	W-07-6*	3	3	3	*	NS	2-SS	*	*	02-2*	2	*	*	*	*-I	*-I
N-nitroso-n-butyl-N-(4-hydroxybutyl)-amine	03817116	W-11-6*	1	1	*	*	NS	7-AP	*	*	03-2*	3	*	*	*	*-I	*-I
N-nitrosodiethylamine	00055185	W-12-6*	2	2	*	*	NS	7-AP	*	*	03-2*	3	*	*	*	*-I	*-I
N-nitrosodimethylamine	00062759	W-13-6*	3	3	*	*	NS	7-PH	*	*	03-2*	3	*	*	*	*-I	*-I
p-nitrosodiphenylamine	00156105	W-10-5*	3	*	*	3	NS	7-AP	*	*	NS-3*	*	*	*	*	*-I	0-B
N-nitroso-N-ethylurea	00759739	W-15-4*	2	2	*	*	NS	7-PH	4	*	02-2*	2	*	*	*	0-B	*-I
N-nitroso-N-methylurea	00684935	W-14-4*	2	2	*	*	NS	7-AP	4	*	01-2*	1	*	*	*	0-B	*-I
N-nitroso-N-methylurethane	00615532	W-17-4*	2	2	*	*	NS	7-AP	4	*	01-2*	1	*	*	*	0-B	*-I
N-nitrosomethylvinylamine	04549400	W-06-7*	3	3	*	*	NS	3-PA	*	*	NS-3*	*	*	*	*	*-I	*-I
N-nitrosomorpholine	00059892	W-11-6*	2	2	*	*	NS	7-AP	*	*	02-2*	2	*	*	*	*-I	*-I
N-nitroso-N-phenylhydroxylamine, ammonium salt	00135206	W-09-6*	*	*	*	*	NS	7-AP	*	*	02-2*	2	*	*	*	*-I	*-I
N-nitrososarcosine	13256229	W-08-7*	1	1	*	*	NS	7-AP	*	*	NS-3*	*	*	*	*	*-I	*-I
pentachloronitrobenzene	00082688	W-12-4*	1	1	*	*	NS	3-PA	*	3	02-2*	2	*	*	*	3-S	*-I
pentachlorophenol	00087865	W-24-4*	7	3	2	7	NS	*-II	*	3	07-2*	*	7	*	*	0-S	7-B
peroxyacetic acid	00079210	W-08-6*	3	3	*	*	NS	3-PA	*	*	02-2*	2	*	*	*	*-I	*-I
piperonyl sulfoxide	00120627	W-12-6*	7	*	*	7	NS	3-PA	*	*	02-2*	2	*	*	*	*-I	*-I
polybrominated biphenyls (PBB)	Class078	W-17-4*	0	0	0	*	NS	*-II	*	3	03-2*	3	*	*	*	4-S	7-B
polychlorinated biphenyls (PCB)	Class079	W-31-3*	7	1	1	7	NS	7-AP	*	3	03-2*	3	*	*	*	4-W	7-B
1,3-propane sultone	01120714	W-07-8*	*	*	*	*	NS	7-AP	*	*	NS-3*	*	*	*	*	*-I	*-I
beta-propiolactone	00057578	W-10-5*	3	3	*	1	NS	7-PH	*	*	NS-3*	*	*	*	*	0-B	0-W
5-propyl-1,3-benzodioxole	00094586	W-10-6*	1	1	0	*	NS	7-AP	*	*	02-2*	2	*	*	*	*-I	*-I
propyleneimine	00075558	W-13-6*	3	3	*	*	NS	7-AP	*	*	03-3*	3	*	*	*	*-I	*-I
semicarbazide	00057567	W-12-5*	2	2	*	*	NS	3-PA	*	7	NS-3*	*	*	*	*	*-I	*-I
styrene	00100425	W-07-5*	2	2	*	2	NS	3-PA	*	*	02-2*	2	*	*	0	*-I	*-I
tetrachloroethylene (perchloroethylene)	00127184	W-11-5*	2	*	*	2	NS	7-AP	*	*	02-2*	2	*	*	*	*-I	0-B
thioacetamide	00062555	W-08-6*	*	*	*	*	NS	3-PA	4	*	01-2*	1	*	*	*	*-I	*-I
4,4'-thiodianiline	00139651	W-11-6*	1	1	*	*	NS	7-AP	*	*	03-2*	3	*	*	*	*-I	*-I
thiourea	00062566	W-09-7*	2	2	*	*	NS	7-AP	*	*	NS-3*	*	*	*	*	*-I	*-I

COMMON CHEMICAL NAME	CAS NUMBER	TOTAL SCORES	ACUTE TOXICITY					CARCN	H.MUT	TERT	OTHER ADVERSE EFFECTS					PERS	BIOA
			TOT	ORA	DER	AQU	INH				TOTAL	ATE/AQU		APE	AAE		
o-toluidine	00095534	H-07-6*	2	2	*	*	NS	3-PA	*	*	02-2*	2	*	*	*	*-I	0-P
o-toluidine hydrochloride	00636215	H-10-6*	1	1	*	*	NS	7-AP	*	*	02-2*	2	*	*	*	*-I	*-I
triaryl phosphate esters	Class084	H-10-7*	7	1	1	7	NS	*-II	*	*	03-2*	3	*	*	*	*-I	*-I
1,1,2-trichloroethane	00079005	H-08-6*	2	1	*	2	NS	3-PA	*	*	03-2*	3	*	*	*	*-I	*-I
trichloroethylene	00079016	H-07-5*	2	1	*	2	NS	3-PA	*	*	02-2*	2	2	*	*	*-I	0-B
trichlorophenols	Class076	H-12-5*	1	1	*	*	NS	7-AP	*	*	03-1*	3	3	*	1	*-I	*-I
2,4,5-trimethylaniline	00137177	W-08-7*	1	1	*	*	NS	7-AP	*	*	NS-3*	*	*	*	*	*-I	*-I
trimethylphosphate	00512561	H-10-5*	1	1	*	*	NS	3-PA	4	*	02-2*	2	*	*	*	*-I	*-I
xylene	01330207	W-07-4*	2	1	*	2	NS	*-II	*	3	02-2*	2	*	*	*	*-I	0-P
Pesticides																	
aldicarb	00116063	H-09-5*	7	7	1	7	NS	*-II	*	*	02-2*	2	*	*	*	0-W	*-I
aldrin	00309002	W-28-2*	7	7	*	7	NS	3-PA	*	7	03-2*	3	*	*	*	1-W	7-B
4-aminopyridine	00504245	H-07-7*	7	7	*	3	NS	*-II	*	*	NS-3*	*	*	*	*	*-I	*-I
anilazine	00101053	H-07-6*	7	2	*	7	NS	0-NC	*	*	NS-3*	*	*	*	*	*-I	*-I
antimycin A	01397940	H-07-7*	7	*	*	7	NS	*-II	*	*	NS-3*	*	*	*	*	*-I	*-I
azinphos-ethyl	02642719	H-07-6*	7	3	2	7	NS	*-II	*	*	NS-3*	*	*	*	*	*-I	*-I
azinphos-methyl	00086500	H-20-5*	7	3	*	7	NS	3-PA	*	3	07-2*	7	*	*	*	*-I	*-I
barban	00101279	W-07-8*	7	2	*	7	NS	*-II	*	*	NS-3*	*	*	*	*	*-I	*-I
bendiocarb	22781233	H-07-8*	7	3	1	7	NS	*-II	*	*	NS-3*	*	*	*	*	*-I	*-I
benomyl	17804352	W-19-4*	7	2	*	7	NS	2-SS	*	7	02-2*	2	*	*	*	1-W	*-I
bromoxynil	01689845	H-07-8*	7	2	*	7	NS	*-II	*	*	NS-3*	*	*	*	*	*-I	*-I
2(p-tert-butylphenoxy)isopropyl-2-chloroethyl sulfite	00140578	W-11-6*	1	1	*	1	NS	7-AP	*	*	03-2*	*	3	*	*	*-I	*-I
captafol	02425061	W-11-6*	7	0	0	7	NS	1-SC	*	*	03-2*	3	*	*	*	*-I	*-I
captan	00133062	H-15-3*	7	1	*	7	NS	3-PA	*	3	02-2	2	*	*	*	0-W	0-B
carbaryl	00063252	H-15-4*	3	2	*	3	NS	2-SS	*	7	03-2*	3	*	*	*	0-H	*-I
carbofuran	01563662	H-07-6*	7	7	0	*	NS	*-II	*	*	NS-3*	*	*	*	*	0-H	0-S
carbophenothion	00786196	H-09-7*	7	3	3	7	NS	*-II	*	*	NS-3*	*	*	*	*	2-S	*-I
chlordane	00057749	H-14-6*	7	2	1	7	NS	3 PA	*	*	NS-3*	*	*	*	*	4-S	*-I
chlordecone	00143500	H-27-4*	7	2	*	7	NS	7-AP	*	3	03-2*	3	*	*	*	*-I	7-B
chlorfenvinphos	00470906	H-10-5*	7	3	3	7	NS	0-NC	*	*	02-2*	2	*	*	*	1-S	*-I
chlorobenzilate	00510156	H-16-5*	7	1	0	7	NS	7-AP	*	*	02-2*	2	*	*	*	0-S	*-I
chlorpyrifos	02921882	H-11-4*	7	3	1	7	NS	*-II	*	*	02-2*	2	*	*	*	1-S	1-B
clonitralid	01420048	W-07-8*	7	0	*	7	NS	*-II	*	*	NS-3*	*	*	*	*	*-I	*-I
coumaphos	00056724	W-09-7*	7	7	*	7	NS	*-II	*	*	02-2	2	*	*	*	*-I	*-I
crotoxyphos	07700176	H-07-8*	7	3	2	7	NS	*-II	*	*	NS-3*	*	*	*	*	*-I	*-I
cycloheximide	00066819	H-09-7*	7	7	*	*	NS	*-II	*	*	02-2*	*	2	*	*	*-I	*-I
DDT	00050293	W-28-3*	7	3	*	7	NS	7-AP	*	0	03-2*	3	*	*	*	4-S	7-B
demeton	08065483	W-07-8*	7	7	7	7	NS	*-II	*	*	NS-3*	*	*	*	*	*-I	*-I
diallate	02303164	W-08-5*	3	2	1	3	NS	3-PA	*	*	02-2*	*	*	*	*	0-S	*-I
diazinon	00333415	H-10-5*	7	7	*	7	NS	*-II	*	*	03-2*	2	3	*	*	0-W	0-B
dibromochloropropane (DBCP)	00096128	W-13-6*	3	2	1	3	NS	7-AP	*	*	03-2*	3	*	*	*	*-I	*-I
dichlone	00117806	H-07-7*	7	1	*	7	NS	*-II	*	*	NS-3*	*	*	*	*	0-S	*-I
dichlorvos	00062737	H-07-6*	7	3	3	7	NS	0-NC	*	*	NS-3*	*	*	*	*	0-S	*-I
dichrotophos	00141662	H-10-6*	7	7	3	2	NS	*-II	*	*	03-2*	*	3	*	*	*-I	*-I
dieldrin	00060571	H-25-5*	7	7	*	7	NS	7-AP	*	*	NS-3*	*	*	*	*	4-S	7-B

COMMON CHEMICAL NAME	CAS NUMBER	TOTAL SCORES	ACUTE TOXICITY								OTHER ADVERSE EFFECTS						
			TOT	ORA	DER	AQU	INH	CARCN.	H.MUT	TERT	TOTAL	ATE/AQU		APE	AAE	PERS	BIOA
dimethoate	00060515	W-10-4*	7	3	*	7	NS	0-NC	*	*	03-2*	3	*	*	*	0-S	*-I
dinocap	39300453	W-08-7*	1	1	*	*	NS	*-II	*	*	NS-3*	*	*	*	*	*-I	7-P
dinoseb	00088857	W-13-5*	7	3	3	7	NS	*-II	*	3	03-2*	*	3	*	*	*-I	0-P
dioxathion	00078342	W-09-6*	7	3	*	7	NS	0-NC	*	*	02-2*	2	*	*	*	*-I	*-I
disulfoton	00298044	W-07-8*	7	7	3	7	NS	*-II	*	*	NS-3*	*	*	*	*	*-I	*-I
endosulfan	00115297	H-14-5*	7	7	3	7	NS	0-NC	*	*	03-2*	3	*	*	*	4-S	*-I
endrin	00072208	H-32-3*	7	7	*	7	NS	0-NC	*	7	07-2*	7	*	*	*	4-S	7-B
EPN	02104645	W-10-7*	7	7	*	7	NS	*-II	*	*	03-2*	3	*	*	*	*-I	*-I
ethion	00563122	W-09-7*	7	3	3	7	NS	*-II	*	*	02-2*	2	*	*	*	*-I	*-I
fensulfothion	00115902	W-08-7*	7	7	7	*	NS	*-II	*	*	NS-3*	*	*	*	*	1-S	*-I
fenthion	00055389	W-09-6*	7	7	*	3	NS	*-II	*	*	02-2*	2	*	*	*	0-S	*-I
fluchloralin	33245395	W-08-6*	7	1	*	7	NS	*-II	*	*	NS-3*	*	*	*	*	0-S	1-B
heptachlor	00076448	W-23-3*	7	3	*	7	NS	3-PA	*	*	03-2*	3	*	*	*	3-S	7-B
heptachlor epoxide	01024573	W-17-6*	7	2	*	7	NS	7-AP	*	*	03-2*	3	*	*	*	*-I	*-I
leptophos	21609905	W-17-6*	7	3	*	7	NS	*-II	*	*	03-2*	3	*	*	*	*-I	7-P
malathion	00121755	W-07-7*	7	1	*	7	NS	*-II	*	*	NS-3*	*	*	*	*	0-S	*-I
methomyl	16752775	W-09-7*	7	3	*	7	NS	*-II	*	*	02-2*	2	*	*	*	*-I	*-I
methoxychlor	00072435	W-13-3*	7	0	*	7	NS	0-NC	*	3	03-2*	3	*	*	*	0-W	0-B
methyl mercaptan	00074931	W-09-5*	7	*	*	7	NS	*-II	*	*	01-2*	1	*	*	1	0-W	*-I
methyl parathion	00298000	W-09-6*	7	3	3	7	NS	*-II	*	*	02-2*	2	*	*	*	0-S	*-I
mevinphos	07786347	W-09-6*	7	7	7	7	NS	*-II	*	*	02-2*	2	*	*	*	0-S	*-I
mexacarbate	00315184	W-07-8*	7	7	1	7	NS	*-II	*	*	NS-3*	*	*	*	*	*-I	*-I
mirex	02385855	W-19-5*	2	2	1	*	NS	7-AP	*	3	07-2*	*	7	*	*	*-I	*-I
monocrotophos	06923224	W-07-8*	7	7	3	7	NS	*-II	*	*	NS-3*	*	*	*	*	*-I	*-I
naled	00300765	W-09-6*	7	3	*	7	NS	*-II	*	*	02-2*	2	*	*	*	*-I	0-P
nicotine	00054115	W-08-7*	7	7	3	3	NS	*-II	*	*	01-2*	1	*	*	*	*-I	*-I
nitrofen	01836755	W-11-5*	2	2	1	*	NS	3-PA	*	*	03-2*	3	*	*	*	*-I	3-B
oxydemeton-methyl	00301122	W-07-8*	7	3	3	7	NS	*-II	*	*	NS-3*	*	*	*	*	*-I	*-I
paraquat	01910422	W-09-6*	3	3	*	*	NS	*-II	*	3	03-2*	*	*	*	*	*-I	*-I
parathion	00056382	W-12-5*	7	7	3	7	NS	3-PA	*	*	02-2*	2	*	*	*	0-S	*-I
phorate	00298022	W-07-7*	7	7	3	7	NS	*-II	*	*	NS-3*	*	*	*	*	0-S	*-I
phosazetim	04104147	W-07-8*	7	7	*	*	NS	*-II	*	*	NS-3*	*	*	*	*	*-I	*-I
phosmet	00732116	W-13-5*	3	3	1	*	NS	*-II	*	7	03-2*	3	*	*	*	0-S	*-I
phosphamidon	13171216	W-07-8*	7	7	3	7	NS	*-II	*	*	NS-3*	*	*	*	*	*-I	*-I
rotenone	00083794	W-09-6*	7	2	*	7	NS	*-II	*	*	02-2*	2	*	*	*	*-I	0-B
silvex propylene glycobutyl ether ester	02317240	W-10-6*	7	1	*	7	NS	*-II	*	*	03-2*	3	*	*	*	0-S	*-I
sodium fluoroacetate	00062748	W-07-8*	7	7	*	*	NS	*-II	*	*	NS-3*	*	*	*	*	*-I	*-I
strychnine	00057249	W-07-8*	7	7	*	*	NS	*-II	*	*	NS-3*	*	*	*	*	*-I	*-I
sulfallate	00095067	W-12-5*	3	1	*	3	NS	7-AP	*	*	02-2*	2	*	*	*	0-S	*-I
sulfotepp	03689245	W-07-8*	7	7	3	*	NS	*-II	*	*	NS-3*	*	*	*	*	*-I	*-I
TDE	00072548	W-13-6*	7	2	1	7	NS	3-PA	*	*	03-2*	3	*	*	*	*-I	*-I
TEPP	00107493	W-07-8*	7	7	*	7	NS	*-II	*	*	NS-3*	*	*	*	*	*-I	*-I
terbufos	13071799	W-07-8*	7	7	7	*	NS	*-II	*	*	NS-3*	*	*	*	*	*-I	*-I
tetrachlorvinphos	00961115	W-08-6*	3	2	*	3	NS	3-PA	*	*	02-2*	2	*	*	*	*-I	*-I
thiram	00137268	W-18-5*	7	1	*	7	NS	1-SC	*	7	03-2*	3	*	*	*	*-I	*-I
toxaphene	08001352	W-28-5*	7	2	1	7	NS	7-AP	*	*	07-2*	*	7	*	*	*-I	7-B
trichlorfon	00052686	W-19-4*	7	2	*	7	NS	3-PA	*	7	02-2*	2	*	*	0	*-I	*-I
trichlorophenoxyacetic acid (2,4,5-T)	00093765	W-17-5*	7	2	*	7	NS	*-II	*	7	03-2*	3	*	*	*	*-I	*-I
trifluralin	01582098	W-11-5*	7	1	*	7	NS	*-II	*	*	02-1*	2	*	*	0	2-S	*-I
ziram	00137304	W-10-6*	7	2	*	7	NS	3-PA	*	*	NS-3*	*	*	*	*	0-S	*-I

COMMON CHEMICAL NAME	CAS NUMBER	TOTAL SCORES	ACUTE TOXICITY TOT	ORA	DER	AQU	INH	CARCN	H MUT	TERI	OTHER ADVERSE EFFECTS TOTAL	ATE/AQU		API	AAE	PERS	BIOA
Drugs, Food Additives, Natural Materials																	
actinomycin D	00050760	H-07-6*	3	3	*	*	NS	2-SS	*	*	02-2*	2	*	*	*	*-I	*-I
citrus red no. 2	06358538	H-09-7*	*	*	*	*	NS	7-AP	*	*	02-2*	2	*	*	*	*-I	*-I
cycasin	14901087	H-10-6*	2	2	*	*	NS	7-AP	*	*	01-2*	1	*	*	*	*-I	*-I
cyclophosphamide	00050180	H-15-5*	3	2	3	*	NS	2-SS	7	*	03-2*	3	*	*	*	*-I	*-I
diethylstilbestrol	00056531	H-09-7*	*	*	*	*	NS	7-HP	*	*	02-2*	2	*	*	*	*-I	*-I
isonicotinic acid hydrazine	00054853	H-11-6*	2	2	*	*	NS	7-AP	*	*	02-2*	2	*	*	*	*-I	*-I
lasiocarpine	00303344	H-08-6*	2	2	*	*	NS	3-PA	*	*	03-2*	3	*	*	*	*-I	*-I
mestranol	00072333	H-09-7*	*	*	*	*	NS	7-AP	*	*	02-2*	2	*	*	*	*-I	*-I
methylthiouracil	00056042	H-09-7*	*	*	*	*	NS	7-AP	*	*	02-2*	2	*	*	*	*-I	*-I
mitomycin C	00050077	H-11-5*	3	3	*	*	NS	2-SS	4	*	02-2*	2	*	*	*	*-I	*-I
monocrotaline	00315220	H-07-6*	2	2	*	*	NS	3-PA	*	*	02-2*	2	*	*	*	*-I	*-I
niridazole	00061574	H-09-7*	2	2	*	*	NS	7-AP	*	*	NS-3*	*	*	*	*	*-I	*-I
nithiazide	00139946	H-08-7*	1	1	*	*	NS	7-AP	*	*	NS-3*	*	*	*	*	*-I	*-I
n-[4(5-nitro-2-furanyl)-2-thiazolyl] acetamide	00531828	H-10-7*	*	*	*	*	NS	7-AP	*	*	03-2*	3	*	*	*	*-I	*-I
phenazopyridine hydrochloride	00136403	H-12-6*	2	2	*	*	NS	7-AP	*	*	03-2*	3	*	*	*	*-I	*-I
phenesterin	03546109	H-09-7*	*	*	*	*	NS	7-AP	*	*	02-2*	2	*	*	*	*-I	*-I
phenobarbitol	00050066	H-13-5*	2	2	*	*	NS	3-PA	*	7	01-2*	1	*	*	*	*-I	*-I
phenytoin	00057410	H-14-5*	2	2	*	*	NS	3-PA	*	7	02-2*	2	*	*	*	*-I	*-I
phenytoin sodium	00630933	H-14-5*	2	2	*	*	NS	3-PA	*	7	02-2*	2	*	*	*	*-I	*-I
propylthiouracil	00051525	H-09-7*	*	*	*	*	NS	7-AP	*	*	02-2*	2	*	*	*	*-I	*-I
uracil mustard	00666751	H-10-6*	7	7	*	*	NS	2-SS	*	*	01-2*	1	*	*	*	*-I	*-I

DATA COLLECTION

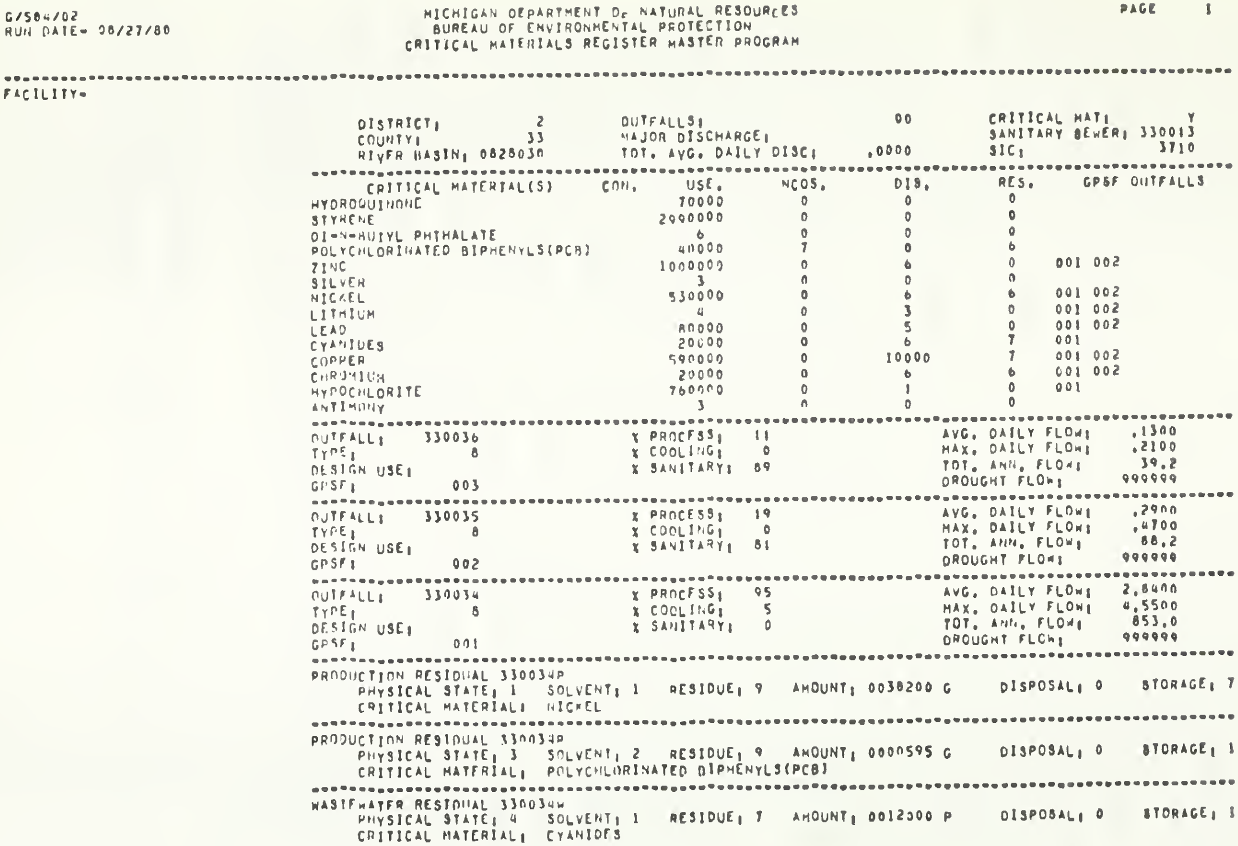
Every person doing business in Michigan who discharges wastewater to the waters of the State or who discharges wastewater in addition to sanitary sewage to a sewer system must annually file a wastewater report. The types and quantities of wastes discharged and use and disposal of Critical Materials must be included in the wastewater report. On October 1 of each year a booklet entitled "Wastewater Report Forms and Instructions" is mailed to approximately 20,000 Michigan businesses. A separate report is required for each location at which a company does business. This booklet contains all of the necessary forms and instructions for filing the annual report and is available upon request from the Office of Toxic Materials Control

"Form I - General Information" is a questionnaire type of form designed to demonstrate what further forms need to be filed by a particular business and to obtain general information on the operation of the facility. "Form II - Wastewater Outfall Report" provides information on the type and volume of discharge. "Form III - Critical Materials Report" provides information on the manufacture, use, discharge, and disposal of Critical Materials. "Form IV - Residuals and Residues Disposal and Storage Report" provides information on the type, source, quantity, disposal method and location, storage procedures, and presence of Critical Materials in sludges and similar wastes resulting from production processes and wastewater treatment. The booklet also contains a description of the surveillance fee calculation method.

All necessary forms must be submitted by December 15 of each year. These forms are then checked for accuracy and completeness and certain information is computer coded, keypunched, and entered into a computer system. The computer system calculates surveillance fees as well as compiling Critical Materials data.

An example of a Critical Materials printout is shown in Table 15. This printout summarizes general information on each facility as well as providing data on use and discharge of Critical Materials. Critical Materials use and discharge codes conrrespond to codes found in the Wastewater Reporting Booklet which represent a quantity interval in pounds (i.e. <1, 1-10, 11-100, 101-500, etc.). The printout also summarizes total quantities of Critical Materials being disposed of in residuals. Facilities can request that their use (but not discharge) of Critical Materials be kept confidential. Confidential use information is indicated by an "X" in the "*confidential*" column corresponding to the Critical Material and the "pound used code" column is left blank. Data is the Critical Materials files can be sorted by geographical location, Standard Industrial Code (SIC), facility number, facility name, specific Critical Material(s), sanitary sewer system, river basin, or type of discharge.

Table 16. Example of a Critical Materials Printout



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G/S04/02                          MICHIGAN DEPARTMENT OF NATURAL RESOURCES                                  PAGE     1
RUN DATE- 08/27/80                 BUREAU OF ENVIRONMENTAL PROTECTION
                                 CRITICAL MATERIALS REGISTER MASTER PROGRAM

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FACILITY-

                        DISTRICT:           2     OUTFALLS:                    00     CRITICAL MAT:          Y
                        COUNTY:            33     MAJOR DISCHARGE:                    SANITARY SEWER: 330013
                        RIVER BASIN: 0828030      TOT. AVG. DAILY DISC:     .0000     SIC:                3710
                    ------------------------------------------------------------------------------------------------
                        CRITICAL MATERIAL(S)     CON.      USE.      NCOS.      DIS.      RES.    GPSF OUTFALLS
                    HYDROQUINONE                          70000        0          0         0
                    STYRENE                             2990000        0          0         0
                    DI-N-BUTYL PHTHALATE                      6        0          0         0
                    POLYCHLORINATED BIPHENYLS(PCB)        40000        7          0         6
                    ZINC                                1000000        0          6         0    001 002
                    SILVER                                    3        0          0         0
                    NICKEL                               530000        0          6         6    001 002
                    LITHIUM                                   4        0          3         0    001 002
                    LEAD                                  80000        0          5         0    001 002
                    CYANIDES                              20000        0          6         7    001
                    COPPER                               590000        0      10000         7    001 002
                    CHROMIUM                              20000        0          6         6    001 002
                    HYPOCHLORITE                         760000        0          1         0    001
                    ANTIMONY                                  3        0          0         0
                    ------------------------------------------------------------------------------------------------
                    OUTFALL:     330036            % PROCESS:     11                 AVG. DAILY FLOW:     .1300
                    TYPE:             8            % COOLING:      0                 MAX. DAILY FLOW:     .2100
                    DESIGN USE:                    % SANITARY:    89                 TOT. ANN. FLOW:       39.2
                    GPSF:           003                                              DROUGHT FLOW:       999999
                    ------------------------------------------------------------------------------------------------
                    OUTFALL:     330035            % PROCESS:     19                 AVG. DAILY FLOW:     .2900
                    TYPE:             8            % COOLING:      0                 MAX. DAILY FLOW:     .4700
                    DESIGN USE:                    % SANITARY:    81                 TOT. ANN. FLOW:       88.2
                    GPSF:           002                                              DROUGHT FLOW:       999999
                    ------------------------------------------------------------------------------------------------
                    OUTFALL:     330034            % PROCESS:     95                 AVG. DAILY FLOW:    2.8400
                    TYPE:             8            % COOLING:      5                 MAX. DAILY FLOW:    4.5500
                    DESIGN USE:                    % SANITARY:     0                 TOT. ANN. FLOW:      853.0
                    GPSF:           001                                              DROUGHT FLOW:       999999
                    ------------------------------------------------------------------------------------------------
                    PRODUCTION RESIDUAL 330034P
                        PHYSICAL STATE: 1   SOLVENT: 1   RESIDUE: 9   AMOUNT: 0038200 G     DISPOSAL: 0    STORAGE: 7
                        CRITICAL MATERIAL:  NICKEL
                    ------------------------------------------------------------------------------------------------
                    PRODUCTION RESIDUAL 330034P
                        PHYSICAL STATE: 3   SOLVENT: 2   RESIDUE: 9   AMOUNT: 0000595 G     DISPOSAL: 0    STORAGE: 1
                        CRITICAL MATERIAL:  POLYCHLORINATED DIPHENYLS(PCB)
                    ------------------------------------------------------------------------------------------------
                    WASTEWATER RESIDUAL 330034W
                        PHYSICAL STATE: 4   SOLVENT: 1   RESIDUE: 7   AMOUNT: 0012300 P     DISPOSAL: 0    STORAGE: 1
                        CRITICAL MATERIAL:  CYANIDES
```

DATA ANALYSIS AND USE

Data on Critical Materials reported by Michigan businesses are used principally in programs designed to identify and prevent toxic substances problems before they develop into crises. The major use of the data is to identify businesses using or discharging amounts of toxic substances which could cause environmental damage. Critical Materials data from each reporting facility are compiled into a data acquisition system and reviewed and analyzed by DNR staff. Judgements on whether a quantity of a Critical Material being discharged has detrimental potential are based on the characteristics of the facility, its receiving water, and the toxicity and other properties of the Critical Material itself. Use data and facility description information are analyzed to determine if cumulative loadings of Critical Materials are likely to be discharged from the facility and whether these discharges are likely to result in environmental degradation. Follow-up action may entail direct contact with the business for further information or clarification and/or a detailed inspection visit to the facility. A facility visit would include an interview with management concerning use, storage, handling, and disposal practices along with the collection of sufficient samples for analysis (*e.g.* raw materials, effluent, sludge, final product). If the facility inspection identifies a problem, a follow-up environmental assessment is conducted to determine the degree and extent of environmental contamination. Administrative procedures or formal legal action would be initiated to achieve abatement should such action be necessary.

Funding for an expanded Critical Materials Register data analysis, follow-up, and compliance monitoring program has been obtained from the U.S.

Environmental Protection Agency via a Toxic Substances Control Act Cooperative Agreement. The objectives of this agreement are to develop: (1) a more efficient, effective, and comprehensive system for analyzing and sorting CMR data utilizing computer systems; (2) an expanded program to investigate potential problems identified by CMR data analysis; (3) a program to monitor and increase compliance with the CMR program; and (4) procedures to integrate the CMR program more closely with existing pollution control programs. The handling and storage of hazard assessment data has been computerized. Computer programs for sorting and analyzing Critical Materials data has been developed to facilitate data review. The funding obtained is being used to expand present staff and laboratory capabilities. Major emphasis is being placed on development of methods which could be adopted by other states to accomplish similar goals.

The CMR data are also used in the development and revision of National Pollutant Discharge Elimination System (NPDES) permits. All NPDES permits are reviewed by the Office of Toxic Materials Control for toxic substances concerns. Part of this review process includes company CMR reports on chemical use and discharge. Recommendations are made by DNR staff for inclusion of monitoring provisions and effluent limitations where necessary. National Pollutant Discharge Elimination System compliance monitoring of discharge points by DNR staff includes consideration of toxic substances covered by monitoring provisions of effluent limitations in the permit, as well as other CMR data not included on the NPDES permit.

All chemicals included on the CMR must be considered in a Pollution Incident Prevention Plan developed by each facility using or storing these materials (Part 5 Rules of Act 245, P.A. 1929, as amended). These rules stipulate that the plan must set forth: (1) procedures for preventing pollution; (2) emergency clean-up procedures; (3) type of surveillance employed to detect possible pollution; and (4) methods of keeping inventories. This plan must be available to employees involved with Critical Materials. In addition, all spills of Critical Materials must be reported to the Department of Natural Resources. A "Pollution Emergency Alerting System" involving a 24-hour per day answering service, trained, on call DNR coordinating staff is available to respond to these spills.

Critical Materials Register data are also made available to other governmental agencies. The Michigan Department of Public Health utilizes the data to identify potential impacts on human health via exposure to water contaminated by Critical Materials. The DNR Air Quality Division can make use of this data to investigate possible fugitive emissions from Critical Materials storage and processes. Identification and elimination of these fugitive emissions will prevent possible adverse impacts in the future.

Selective computer retrievals are also made for specific reasons. These retrievals may be made to: (1) investigate, identify, and qualify patterns of use or discharge of specific Critical Materials; (2) make selective mailings to obtain further information on a Critical Material; or (3) send regulation and warning notices to businesses which have Critical Materials use and discharge patterns similar to a known problem.

APPENDICES

APPENDIX 1: Proposed List of Hazardous Materials to be Screened for the 1977 Critical Materials Register

INORGANIC COMPOUNDS

- Aluminum
  - fluoride
  - sulfate
- Ammonia compounds
  - ammonia, acetate, benzoate, bicarbonate, bichromate, bifluoride, bisulfite, bromide, carbamate, carbonate, chloride, chromate, citrate, fluoborate, fluoride, hydroxide, hypophosphite, iodite, nitrate, oxalate, pentaborate, persulfate, silicofluoride, sulfamate, sulfide, sulfite, tartrate, thiocyanate, thiosulfate
- Antimony
  - pentachloride, pente fluoride, potassium tartrate, trihalide, trioxide
- Arsenic
  - acid, disulfide, pentoxide, trichloride, trioxide, trisulfide
- Asbestos
- Barium cyanide
- Beryllium
  - chloride, fluoride, nitrate
- Cadmium
  - acetate, bromide, chloride
- Calcium
  - arsenate, aresenite, carbide, chromate, cyanide, dodecylbenzenesulfonate, hydroxide, hypochlorite, oxide
- Chlorine
- Chromium
  - chromic acetate, acid and sulfate, chromous chloride, chromyl chloride
- Cobalt
  - halides, formate, sulfamate
- Copper
  - cupric acetate, acetoarsenite, chloride, formate, glycinate, lactate, nitrate, oxalate, subacetate, sulfate, tartrate. Cuprous halides
- Cyanides
- Iron
  - ferric ammonium citrate, ammonium oxalate, chloride, fluoride, nitrate, sulfate. Ferrous ammonium sulfate, chloride and sulfate
- Lead
  - acetate, arsenate, chloride, fluoborate, fluoride, iodide, nitrate, stearate, sulfate, sulfide, tetraacetate tetraethyl, thiocyanate, thiosulfate, tungstate
- Lithium
  - bichromate, chromate
- Mercury
  - mercuric acetate, cyanide, nitrate, sulfate, thiocyanate. Mercurous nitrate
- Nickel
  - ammonium sulfate, chloride, formate, hydroxide, nitrate, sulfate
- Phosphorous
  - oxychloride, pentasulfide, trichloride
- Potassium
  - arsenate, arsenite, bichromate, chromate, cyanide, hydroxide, permargannte
- Selenium
  - oxide
- Sodium
  - arsenate, arsenite, bichromate, bifluoride, bisulfite, chromate, cyanide, fluoride, hydrosulfide, hydroxide, hypochlorite, methylate, nitrite, phosphate, selenite, sulfide
- Stannous
  - fluoride
- Strontium
  - chromate
- Sulfur
  - monochloride
- Thallium
- Uranium
  - peroxide, uranyl acetate, nitrate, sulfate
- Vanadium
  - pentoxide, vanadyl sulfate
- Zinc
  - acetate, ammonia chloride, bichromate, borate, carbonate, cyanide, formate, halides, hydrosulfite, Nitrate, phenolsulfonate, phosphide, potassium chromate, silicofluoride, sulfate, sulfate monohydrate
- Zirconium
  - acetate, nitrate, oxychloride, potassium fluoride, sulfate, tetrachloride

ORGANIC COMPOUNDS

- Acetaldehyde
- Acetic Acid
- Acetone Cyanohydrin
- Acid Chlorides
  - benzoyl chloride, diethylcarbamoyl chloride, dimethylcarbamoyl chloride,
- Acridine
- Acrolein
- Acrylonitrile
- Adiponitrile
- Aliphatic Amines
  - butyl amine, diethyl amine, dimethyl amine, EDTA, ethylene diamine, monoethyl amine, monomethyl amine, triethyl amine, trimethyl amine
- Allyl Alcohol (vinylcarbinol)
- Allyl Chloride
- Amyl Acetate
- Anhydrides
  - acetic, maleic, propionic, phthalic
- Anthroquinones
  - 1,2 dihydroxy - 9,10 anthraquinone (alizarin)
  - 1,4 dihydroxy - 9,10 anthraquinone (quinizarin)
  - 1,2,3 trihydroxy - 9,10 anthraquinone (anthragallol)
  - 1,2,4 trihydroxy - 9,10 anthraquinone (purpurin)
  - 1,4 - diamino - 9,10 anthraquinone
- Aromatic Amines
  - aniline, benzidine, o-chloroaniline,
  - 3,3' dichlorobenzidine
  - naphthylamines, 1 and 2
  - 4,4' methylenebis [2-chloro] aniline
  - 4,4' methylenebis [2-methyl] aniline
  - dimethylaminoacetyl 2, 4, 6 trimethylaniline
  - 4-amino biphenyl
  - 2- aminobiphenyl
- Azide, sodium
- Aziridines
  - aziridine (ethylenimine)
  - 2-methyl aziridine (propylenimine)
  - 2-(1-aziridine) ethanol
- Azo Dyes
  - azobenzene
  - CI solvent yellow #1 (4-aminoazobenzene)
    - #2 (4-dimethylaminoazobenzene)
    - #3 (o-aminoazo toluene)
- Benzaldehyde
- Benzene
- Benzoic Acid
- Benzonitrile

APPENDIX 1: (continued)

ORGANICS (CONTINUED)

- Benzyl bromide
- Benzyl chloride
- Brucine (2,3 dimethoxystrychnine)
- Butanol
- p-bromoanisole
- Butyl acetate
- Butyric acid
- Carbamic acid, ethyl ester
- Carbazole
- Carbon disulfide
- Catechol
- Chlorendic acid
- Chlorinated benzenes
- Chlorinated naphthalenes
- Chlorinated phenols
- Chloroalkyl ethers
  - bis (chloromethyl) ether
  - bis (2-chloroethyl) ether
  - 2-chloroethyl vinyl ether
  - methylchloromethylether
- 1-chloro-2-propanol
- Chloroprene (2-chloro 1,3 butadiene)
- 2-chloroethanol
- Chlorosulfonic acid
- Cresols
  - p,o and m cresol
  - chlorinated at all sites
- Crotonaldehyde
- Cumene
- Cyclohexane
- Diazomethane
- Dichlorobenzidines
- 1,4-dichlorobutene (1,4-dichloro-2-butene)
- Dichloroethylenes
- Dichloropropanes
- Dichloropropenes
- Dicyclopentadiene (biscyclopentadiene)
- Diethylbenzene
- Dimethylphenol 2,4
- Dinitrotoluenes
- Dioxane
- Diphenylhydazines
- Dodecylbenzenesulfonic acid
- Endosulfans
- Epoxides
  - chloromethyl oxirane (epiclorohydrin)
  - methyl oxirane (propylene oxide)
  - mesityl oxide
  - oxirane (ethylene oxide)
  - oxiranemethanol (glycidol)
  - phenyl oxirane (glycidaldehyde)
  - styrene oxide
- Ethyl Acrylate
- Ethylbenzene
- Ethylene dibromide
- Ethylene dichloride
- Fluoranthene
- Formaldehyde
- Formic acid
- Fumaric acid
- Haloethers
  - bis (dichloroisoporopyl) ethers
  - bis (chloroethoxy) ethers
  - bromodiphenyl ethers
  - chlorodiphenyl ethers
  - polychlorinated diphenyl methane
- Halogenated saturated hydrocarbons
  - acetyl chloride
  - acetyl bromide
  - bromoform
  - carbon tetrachloride
  - chlorodibromo methane
  - chloroform
  - chlorinated ethanes
  - 1,2 dibromo-3-chloropropane
  - dichlorobromomethane
  - dichlorodifluoromethane
  - methyl chloride
  - methyl bromide
  - methyl iodide
  - trichloro fluoromethane
  - trichloronitro methane (Chloropicrin)
- Hexachlorbutadiene
- Hexachloropentadiene
- Hexachlorocyclohexane
- Hexamethylenetetramine
- Hexamethylphosphoramide
- Hydrazines
  - carboxamide hydrazine
  - dimethyl hydrazines
  - hydrazine
- Hydroquinone
- Hydroxylamines
  - N-methyl hydroxylamines
  - O-methyl hydroxylamines
  - hydroxylamine
- Isophorone
- Isopreoe
- Isopropanolamioe dodecylbenzene sulfonate
- Lactonitrile
- Maleic acid
- Methylene chloride
- Methyl methacrylate
- Mesitylene
- Mesityl oxide
- Naphthalenes
  - 1,8 ethylene naphthalene (acenaphthane)
  - methyl naphthalene
  - naphthalene
  - naphthol
  - 1-(1-naphthyl) thiourea
- Naphthenic acid
- Nitrobenzenes
- Nitrofurans
  - 2-nitrofuran
  - N-[4nitro-2-furanyl-2-thiazoyl] acetamide
  - N-[4nitro-2-furanyl-2-thiazoyl] formamide
- Nitrophenols
- Nitrosamines
  - N-nitrosodimethylamine
  - N-nitrosodi-n-propylamine
  - N-nitrosodiphenylamine
  - diethylnitrosoamine
- Paraformaldehyde
- Pentabromotoluene
- Peroxides
  - bis (dimethylethyl) peroxide
  - 3-carboxypropaneperoxoic acid
  - 1,1 dimethylbenzyl hydro peroxide
  - 1,1 dimethylethyl hydro peroxide
  - hydrogen peroxide
  - peracetic acid (pecoxy acetic acid)
  - succinic acid peroxide
  - tert butyl peroxide
- Phenol
- Phosgene
- Phosphoric acid esters
  - trimethyl phosphate
  - triethyl phosphate
  - tris (2,3 dibromopropyl)-phosphate
- Phthalate esters
  - bis (2-ethylhexyl) phthalate
  - butylbenzyl phthalate
  - diethyl phthalate
  - dimethyl phthalate
  - di-n-butyl phthalate
- Polynuclear aromatics
  - acenaphthylene
  - anthracene
  - benzanthracenes
  - benzofluoranthenes
  - 3,4 benzpyrene
  - 1,12 benzperylene
  - chrysene

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APPENDIX 1: (continued)

ORGANICS (CONTINUED)

-
  - dibenzanthracenes
  - fluorene
  - idenopyrenes
  - phenanthrene
- Polychlorinated biphenyls
- Polybrominated biphenyls
- Propiolactone (oxetanone)
- Propionic acid
- Propyl alcohol
- Pyridines
  - dichlorovinylsulfonyl pyridine
  - tetrachloropropylsulfonyl pyridine
  - trichloropropylsulfonyl pyridine
  - pyridine
  - L-3-(1-pyrrolidyl) pyridine (Nicotine)
- Pyrethins
- Quinoline
  - 8-hydroxyquinoline
- Quinone
- Resorcinol
- Strychnine
- Styrenes
  - octachlorinated
  - polychlorinated
  - styrene
- Alkyl sulfates
  - diethyl sulfate
  - dimethyl sulfate
- Sultones
  - 1,4 butene sultone
  - 1,3 propane sultone
- 2,3,7,8 tetrachlorodibenzo-p-dioxin (TCDD)
- Tetrachloroethylene
- Toluene
- Toluene diisocyanate
- Triethanolamine dodecyl benzenesulfonate
- Triazenes
  - 3,3-dimethyl-1-phenyl triazene
  - 1-(p-chlorophenyl)-3,3 dimethyl triazene
- Trichloroethylene
- Vinyl acetate
- Vinyl chloride
- Vinylidene chloride
- Vinyl toluene
- Xylenes
- Xylenol

PESTICIDES

- Aldrin/dieldrin
- Botran (dichloran)
- Captan
- Carbaryl
- Casoran (Dichlobenil)
- Chlordane (Octachlor)
- Coumaphos
- Dalapon
- DDT
- Diazinon (Basudin)
- Dicamba
- Dichlobenil
- Dichlone (phygon)
- Dichlorvos (DDVP)
- Diquat
- Disulfoton (Di-syston)
- Dithane (Nembam, Maneb, Zineb)
- Diuron (Karmex)
- Dursban
- Endrin
- Ethion (Nialate)
- Folpet (Phtaltan)
- Furfural
- Guthion (Gusathion)
- Heptachlor
- Heptachlor epoxide
- Kelthane
- Kepone
- Lindane (gamma-BHC)
- Malathion
- Mercaptan
- Methoxyclor
- Methyl mercaptan
- Mevinphos (Phosdrin)
- Mirex
- Naled (Dibrom)
- Parathion
- Picloram
- Rotenone
- Silvex (Kuron)
- Toxaphene
- Trichlorfon
- Zectran
- 2,4-D
- 2,4,5-T

APPENDIX 2: List of Priority Chemical Substances for Further Evaluation by the 1978 CMR Advisory Committee

Acetaldehyde, Chloro-
Acetic acid, Benzyl ester
Acetic acid, Chloro-
Acetic acid, Diazo-, ethyl ester
Acetic acid, (Ethylenedinitrilo) tetra-,
  tetrasodium salt
Acetic acid, Iminodi-
Acetophenone, Chloro-
Acetylaminofluorene
Acetylene
Acrylamide
Acrylic acid
Acrylic acid, 2-Cyano-, methyl ester
Acrylic acid esters
  Acrylic acid, ethyl ester
  Acrylic acid, 2-ethylhexyl ester
Alkoxy alkanols
  Ethanol, 2-Butoxy
  Ethanol, 2-(2-Butoxyethoxy)-
  Ethanol, 2-Ethoxy
  Ethanol, 2-(2-Ethoxyethoxy)-
  Ethanol, 2-Methoxy-
  Ethanol, 2-(2-Methoxyethoxy)-
  Ethanol, 2-(2-(2-Methoxyethoxy)ethoxy)-
  2-Propanol, 1, 1'-Oxydi-
Alkyl adipates
  Adipic acid, Bis (2-ethylhexyl) ester
  Adipic acid, n-octyl n-decyl ester
Alkyl amines
  Dodecylamine
  Isopropylamine
  Methanamine, N, N-Dimethyl-
Alkyl epoxides
  Butane, 1, 2:3-Diepoxy-
  Butane, (+-)-1,2:3,4-Diepoxy-
  Butylene oxide
Alkyl phthalates (short chain)
  Dibutyl phthalate
  Dimethyl terephthalate
Alkyl phthalates (long chain)
  Dicyclohexyl phthalate
  Diisodecyl phthalate
  Diisooctyl phthalate
  Dioctyl phthalate
  Ditridecyl phthalate
  n-Octyl n-decyl phthalate
Alkyl sulfates and sulfonates, linear
  Monododecyl sulfate, sodium salt
  Octyl sulfate, sodium salt
  Tridecyl sulfate, sodium salt
Allylamine
Aluminum distearate
Ambutonium bromide
Ammonium, Alkyl (C_8-C_{18})
  dimethyl 3,4-dichlorobenzyl-, chloride
Aniline, 3,4-Dichloro-
Aniline, N,N-Diethyl-
Aniline, N,N-Dimethyl
Aniline, 4,4'-Methylenedi-
Aniline, N-Methyl-N,2,4,6-tetranitro-
Aniline, p-Nitro
Aniline, 2,4,5-Trimethyl-
p-Anisidine
Anthranilic acid
Azelate, Di(2-ethylhexyl)-
Azinphos-ethyl
Azoxybenzene
Benzaldehyde, Nitro
Bendiocarb
Benzamine, 4,4' Sulfonylbis
Benzene, Chloro dinitro-
  Benzene, 1-Chloro-2,4-dinitro-
  Benzene, 2-Chloro-1,3-dinitro
Benzene, Chloronitro-
  Benzene, 1-Chloro-2-nitro-
  Benzene, 1-Chloro-3-nitro-
  Benzene, 1-Chloro-4-nitro-
Benzene, Dinitroso-
Benzene, Divinyl,
Benzene, 1,2-(Methylenedioxy)-4-propenyl-
Benzene, Pentachloronitro-
Benzimidazole, 6-Nitro-
Benomyl
Benzophenone
Benzophenone,4,4'-Bis (dimethylamino)-
p-Benzoquinone dioxime
Benzothiazole
Benzothiazole, 2,2'-Dithiobis-
Benzothiazole,2-(Morpholino-thio)-
2-Benzothiazolesulfenamide, N-Cyclohexyl-
Benzoyl peroxide
Benzyl alcohol
Beryl
Biphenol
Biphenyl
Biphenyl, 4-Bromomethyl-
Biphenyl, Chlorofluoro-
Biphenyl, bis (Chloromethyl) octachloro-
2,4'-Biphenyldiamine
Biphenyl, 4-Nitro
Biphenylol, Chloro-
Bismuth and Bismuth Compounds
  Bismuth
  Bismuth, Tris (dimethyldithiocarbamato)-
1,3-Butadiene
Butadiene, 2-Chloro-
1-Butene
2-Butene
Butylbromides
  1-Bromobutane
  2-Bromobutane
  2-Bromo-2-methyl propane
Carbon tetrabromide
Carbon tetrafluoride
Cellulose tetranitrate
Chloral hydrate
Chloramine
Chlorinated adipate
Chlorinated anisole
Chlorinated paraffins, 34-64% chlorine
Chlorinated stilbenes
Chlorothalonil
m-Cresol,4,4'-Butylidenebis (6-tert-butyl)-
P-Cresol,2,6-Dinitro
m-Cresol,4,4'-Thiobis (6-tert-butyl)-
Cyclohexane
Cyclohexane, Pentachlorobromo
Cyclohexanol
Cyclohexanol, Methyl-
Cyclohexanone
Cyclohexanone, 2-methyl-
Cyclohexene
1-Cyclohexene, 4-Vinyl-
1,3-Cyclopentadiene
Cyclopentane
Cyclopentane, Methyl-
Decaborane (14)
Dialkyl dithio carbamates
Dibutalin, (N-Sec-Butyl-4-tert-butyl,2,6-dinitroaniline)
Diethylamine, 2,2'-Dichloro-N-methyl-
N,N-Diethylenediamine
Dimethyl sulfoxide
Diphenylamine
Diphenylamine, 4-Isopropoxy-
Diphenylamine, 4-Nitroso
Diphenylhydrazine
Dithianon
Drazoxolon
Endothal
Ethane, Bromo
Ethane, Chloro
Ethane, Chlorodifluoro-
Ethane, 1,2, Dichloro-
Ethane, 1,1,2,2-Tetrabromo

APPENDIX 2: (continued)

- Ethane, 1,1,1-Trichloro-
- Ethane, 1,1,2-Trichloro-
- Ethanol,2-Amino
- Ethanol, 2-Dimethylamino
- Ethanol,2,2'-Iminodi-
- Ethanol,2,2',2"-Nitrilotri-
- Ethyl Chloroformate
- Ethylene
- Ethylene, Bromo-
- Ethylene diamine, N-(1-Naphthyl)-dihydrochloride
- Ethylene, Tetrachloro-
- Ethylene, Trichloro-
- Ethylenediamine, N-1(1-Naphthyl)-dihydrochloride
- Fenitrothion
- Ferrocene
- Flame retardants (brominated alcohols)
  - Dibromobutenediol
  - Dibromoneopentyl glycol
  - 2,3-Dibromopropanol
  - Tribromoneopentyl alcohol
- Flame retardants (brominated aromatic compounds)
  - Decabromodiphenyl ether
  - Bis (2,4,6, tribromophenoxy) ethane
  - Hexabromobenzene
  - Hexabromocyclododecane
  - Pentabromotoluene
  - Tetrabromophthalic anhydride
- Flame retardants (halogenated phosphates and phosphonates)
  - Bis (2-chloroethyl) vinyl phosphonate
  - Diethyl 2- bromoethylphosphonate
  - Tris (4-bromophenyl) phosphate
  - Tris (2-chloroethyl) phosphate
  - Tris (2,3-dichloropropyl) phosphate
  - Tris (2,4,6-tribromophenyl) phosphate
- Flame retardants (hexachlorocyclopentadiene derivatives)
  - Bis (chlroendo) bicyclopentadiene
  - Bis (chlorendo) cyclooctadiene
  - Bis (chlorendo) furan
  - Chlorendic anhydride
  - Chlorondic salts
  - Chlorendocyclooctadiene
  - Bromochlorendocyclooctadiene
  - 2,3,4,5-Tetrabromophenyl-2,2a,2a,3,4,5-hexachloro-bicycloheptadiene
- Flame retardants (Miscellaneous halogenated compounds)
  - Tetrabromobisphenol A, Bis (2,3-dibromopropyl ether)
  - Tetrabromophthalic enydride
  - 2,2',6,6'-Tetrabromo-3,3',5,5'-tetramethyl-4,4'-dihydroxybiphenyl
  - Tetrachlorobisphenol A
  - Tetrachlorophthalic anhydride
- Flame retardants (phosphonium compounds)
  - Tetrakis (hydroxymethyl) phosphonium bromide
  - Tetrakis (hydroxymethyl) phosphonium chloride
  - Tetrakis (hydroxymethyl) phosphonium hydroxide
  - Tetrakis (hydroxymethyl) phosphonium sulfate
- Fluchloralin
- Fluorescent brightening agents
  - 4,4'-Diamino-2,2'-stilbenedisulfonic acid
- Fluoroacetamide
- Fluorocarbons
  - Ethane, 1-Chloro-1,1-difluoro-
  - Methane, chlorodifluoro-
  - Methane, Dichlorofluoro-
- Formamide
- Formamide,N,N-Dimethyl-
- Formate, Ethylchloro-
- Furan, tetrahydro-
- Glycols (low molecular weight)
  - Diethylene glycol
  - Ethylene glycol
  - 1,2-Propanediol
  - Tetraethylene glycol
  - Triethylene glycol
- Heptane
- Heptene
- 1,6-Hexanediamine
- Hexanes and other C_6 hydrocarbons
  - Cyclohexane
  - Hexane
  - Hexane, Tetrabromodihydroxy
  - Pentane, 2-Methyl-
- Hexanol,2-Ethyl-
- Methyl hydrazines and other derivatives
  - Hydrazine, Methyl-
  - Hydrazine, monohydrate
- Hydroxylamine, N-Phenyl-
- Isocyanic acid, p-chlorophenyl ester
- Isocyanic acid, 3,4-dichlorophenyl ester
- Isophthalic acid
- Ketones, asymmetric
  - 2-H-Azepin-2-one, Hexahydro-
  - 2-Butanone
  - Cyclohexanone, 2-Methyl-
  - 2-Heptanone
  - 3-Heptanone, 5-Methyl-
  - 2-Hexanone
  - 2-Hexanone, 5-Methyl-
  - 2-Pentanone, 4-Methyl-
- Lauroyl peroxide
- Ligninsulfonic acid, calcium salt
- Ligninsulfonic acid, ferrochrome salt
- Maleic acid, dibutyl ester
- Maleic hydrazide
- Manganese
- Melamine
- p-Menthane-8-hydroperoxide
- Mercaptans
  - Dodecyl Mercaptan
- Mercaptobenzothiazole
- Merthect
- Methacrylic acid esters
  - Methacrylic acid, butyl ester
  - Methacrylic acid, ethyl ester
  - Methacrylic acid, Methyl ester
- Methane, Bis (2-Chloroethoxy)-
- Methane, Bromo
- Methane, Bromochloro
- Methane, Bromodichloro-
- Methane, Bromotrifluoro-
- Methane, Chloro-
- Methane, Chlorodifluoro-
- Methane, Dibromo-
- Methane, Dibromochloro-
- Methane, Dichlorofluoro-
- Methane, Dimethoxy
- Methane, Tribromo-
- Methylacrylonitrile
- Methylbenzothiopene
- Morpholine
- Naphthalene, Decahydro-
- Naphthalene, 1-Nitro
- 2-Naphthylamine, N,N-Bis (2-chloroethyl)-
- 2-Nahpthylamine, N-Phenyl-
- Nemacur
- Nitrilotriacetic acid
- Nonachlor
- Nonene
- Norflurazon
- Octadecanoic acid, 9, 10-Epoxy, butyl ester
- Octane
- Omethoate
- Oxalic acid
- 2H-1,3,2-oxyazaphosphorine,2-(Bis(2-chloroethyl)amino) tetrahyoro-,2-oxide
- Pentane
- 1.3-Pentanediol,2,3,4-Trimethyl-
- 1-Pentanol,2-Methyl-
- 1-Pentanol,4-Methyl-
- Peroxide, Bis(2,2-dimethylbenzyl)
- Peroxide, Bis (dimethylethyl)

APPENDIX 2: (continued)

Peroxybenzoic acid, t-butyl ester
Phenol, Dodecyl-
Phenol,4,4'-Isopropylidenedi-
Phenol, Nonyl-
Phenol, Tribromo-
Phenylacetyl Chloride
m-Phenylenediamine
o-Phenylenediamine
p-Phenylenediamine
p-Phenylenediamine, dihydrochloride
p-Phenylene diamine, N,N'-Diphenyl-
o-Phenylenediamine, 4-Nitro-
Phosphine oxide, Tris(1-aziridinyl)-
Phosphonic acid, bis(2-chloroethyl)(1-hydroxyethyl) ester
Phosphorene, Pentachloro-
Phosphorotrithioic acid, s,s,s,-tributyl ester
Phthalic acid
Phthalic anhydride
Picric acid
Pigment blue 15
Pigment green 7
Pigment yellow 12
Pigment yellow 13
Pigment yellow 14
Pigment yellow 17
Polychlorinated diphenyl ethers
Polychlorinated triphenyls
Propene, 2-Bromo-2-Methyl
Propane, 1-Nitro-
Propane, 2-Nitro-
Propane, 1,1'-Oxybis-
Propene, 2,2'-Oxybis-
Propane, 1,2,3-Trichloro-
2-Propanol, 1-Chloro-
Propanol,2,3 Dibromo-
2-Propenone, 1, Chloro-
2-Propanone,1,1,1,3,3,3-Hexafluoro-
Propene
Propene,1-Chloro-2-methyl-
Propene,3-Chloro-2-methyl
Propene,2-Methyl-
2-Propenoic acid, butyl ester
Propionitrile, 3-Amino-
Quinoline,1,2-Dihydro-2,2,4-trimethyl-
8-Quinolinol
Sebacic acid, Bis (2-ethylhexyl)ester
Silicones, organo-
  e.g. polymethylsiloxanes
Sodium dibutyldithiocarbamate
Sodium thiosulfate, pentahydrate
Stearic acid, Methyl ester
Stilbene
Styrene, Methyl ester
Temophos
Terephthalic acid
Tetrabromophthalic Anhydride
Tetrahydrofuran
Thionazin
Thiophanate methyl
Thiophene,2,5-Dihydro-,1,1-dioxide
Thiophene, Tetrahydro-1,1-dioxide
Thiphenamil hydrochloride
Titanium dioxide
Toluene
Toluene, o-Chloro-
Toluene, p-Chloro-
Toluene,2,4,(and 2,6)-Dinitro-
Torak
Triallylamine
s-Triazine, Hexahydro 1,3,5-trinitro-
s-Triazine,2,4,6-Trichloro-
s-Triazine-2,4,6(1H,3H,5H)-trione, 1,3,5-Trichloro-
Trichloronate
Triethylenetetramine
Trimellitic Anhydride
Xylene
Xylidine

APPENDIX 3: List of Priority Chemical Substances for Further Evaluation by the 1979 CMR Advisory Committee

Acenaphthene
Acenaphthylene
Acetic acid
Acetic anhydride
Allyl chloride
2-Aminoethanol
Anilazine
o-Anisidine
Anthracene
Asbestos
Benzo(a)anthracene
3,4-benzofluoranthene
Benzo(k)fluoranthene
1,12-benzo perylene
Bifenox
Biphenyl
Bis(2-chloroethoxy)methane
Bis(2-chloroisopropyl)ether
Bis(2-ethylhexyl)phthalate
p-Bromoanisole
Bromoform
4-Bromophenyl phenyl ether
Bromoxynil
Buctril
t-Butylamine
Butyl benzyl phthalate
Butyl glycidyl ether
Camphor
Chloroacetaldehyde
2-Chloroacetophenone
Chlorobenzene
Chlorobenzilate
Chlorodibromomethane
2-Chloroethyl vinyl ether
2-Chloronaphthalene
4-Chlorophenyl phenyl ether
Chrysene
Dibenzo(a,h)anthracene
Dichlorobromomethane
Dichlorodifluoromethane
1,1-dichloroethane
1,2-dichloroethane
1,1-Dichloroethylene
1,2-trans-dichloro ethylene
1,3-Dichloropropylene
2(Diethylamino)ethanol
Diethyl phthalate
N,N-Dimethylacetamide
2,4-Dimethylphenol
Dimethyl phthalate
4,6-Dinitro-o-cresol
2,4-Dinitrophenol
2,4-Dinitrotoluene
Di-n-octyl phthalate
Dioxathion
Ethanethiol
Ethylbenzene
Ethylene thiourea
Fluoranthene
Fluorene
Fujithion
Heptachlor epoxide
Heptachlorostyrene
Hexachloroethane
Indeno(1,2,3-cd)pyrene
Isophorone
Kathon
Ketene
Mercaptobenzothiazole
N-Methylaniline
Methyl-benzimidazole carbamate
Methyl bromide
Methyl chloride
Methylene bis(thiocyanate)
Methylene chloride
α-Methylnaphthalene
NABAM
Nitrobenzene
N-Nitroso-diphenylamine
N-Nitroso-di-N-propylamine
m-Nitrotoluene
o-Nitrotoluene
p-Nitrotoluene
Octachlorostyrene
Pentabromobenzene
Pentabromotoluene
Phenanthrene
Phenylhydrazine
Potassium titanate fiber
Pyrene
Tetrachlorobenzene
1,1,2,2-Tetrachloroethane
Toluene
1,2,3-Trichlorobenzene
1,2,4-Trichlorobenzene
1,4,6-Trichlorobenzene
1,1,1-Trichloroethane
1,1,2-Trichloroethane
Trichlorofluoromethane

APPENDIX 4: List of Priority Chemical Substances for Further Evaluation by the 1980 CMR Advisory Committee

I. Chemicals obtained from the IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans.

A. IARC Human Positive

N,N-Bis(2-chloroethyl)-2-naphthylamine
Diethylstilbestrol
Melphalan
Mustard gas

B. IARC Potential Human

Beryllium & Beryllium compounds
Chlorambucil
Cyclophosphamide
Dimethylcarbamoyl chloride
Dimethyl sulfate
Ethylene oxide
Oxymetholone
Phenacetin
Tris(1-aziridinyl)phosphine sulfide

C. IARC Animal Positive/Potential Animal

Actinomycins
O-Aminoazotoluene
2-Amino-5-(5-nitro-2-furyl)-1.3,4-Thiadiazole
Aramite
Azaserine
Benzo[b]fluoranthene
Benzyl violet 3B
B-Buryolactone
Chloramphenicol
Citrus Red No. 2
Cycasin
Daunomycin
N,N'-Diacetylbenzidine
4,4'-Diaminodiphenyl ether
2,4-Diaminotoluene
Dibenz[a,h]acridine
Dibenz[a,j]acridine
7H-Dibenzo[c,g]carbazole
Dibenzo[a,e]pyrene
Dibenzo[a,h]pyrene
Dibenzo[a,i]pyrene
1,1-Dichloroethane
3,3'-Dichloro-4,4'-diaminodiphenyl ether
1,2-Diethylhydrazine
Diethyl sulfate
Dihydrosafrole
3,3'-Dimethoxybenzidine
t-2[(Dimethylaminc)methylimino]-5-[2-(5-nitro-2-furyl)vinyl]-1,3,4-oxadiazole
3,3'-Dimethylbenzidine
1,4-Dioxane
Ethinyloestradiol
Ethylmethanesulphonate
2-(2-Formylhydrazino)-4-(5-nitro-2-furyl)thiazole
Haematite (Ferric oxide)
Hexamethylphosphoramide
Ideno[1,2,3-cd]pyrene
Isonicotinic acid hydrazide
Lasiocarpine
Merphalan
Mestraool
Methylazoxymethanol acetate
4,4'-Methylenebis(2-methylaniline)
Methylmethanesulphonate
N-Methyl-N'-nitro-N-nitrosoguanidine
Methylthiouracil
Mitomycin C
Monocrotaline
5-(Morpholinomethyl-3-[5-nitro-furfurylidene)-amino]-2-oxazolidinone
Niridazole
5-Nitroacenaphthene
1[(5-Nitorfurfurylidene)amino]-2-imidazolidine
N-[4-(5-Nitro-2-furyl)-2-thiazolyl]acetamide
Nitrogen Mustard
Nitrogen Mustard Hydrochloride
Nitrogen Mustard N-oxide
Nitrogen Mustard N-oxide Hydrochloride
N-Nitrosodi-n-butylamine
N-Nitrosodiethanolamine
N-Nitrosodimethylamine
N-Nitroso-n-ethylurea
N-Nitrosomethylethylamine
N-Nitroso-N-methylurea
N-Nitroso-N-methylurethane
N-Nitrosomethylvinylamine
N-Nitrosomorpholine
N-Nitrosonornicotine
N-Nitrosopiperidine
N-Nitrosopyrrolidine
N-Nitrososarcosine
Oestradiol-17B
Oestrone
Oil Orange SS
Phenobarbital
Phenylbutazone
N-Phenyl-2-naphthylamine
Phenytoin
Phenytoin sodium
Ponceau MX
Ponceau 3R
Propylthiouracil
Reserpine
Safrole
Sterigmatocystin
Streptozotocin
Testosterone
Thioacetamide
O-Toluidine
Tris(aziridinyl)-p-benzoquinone
Trypan blue
Uracil mustard
Urethane
Vinylidene chloride

II. Chemicals obtained from the National Cancer Institute Carcinogenesis Technical Report Series

Acronycine (drug)
2-Aminoanthraquinone
3-Amino-4-ethoxyacetanilide
3-Amino-9-ethylcarbazole (hydrochloride)
1-Amino-2-methylanthraquinone
4-Amino-2-nitrophenol
2-Amino-5-nitrothiazole (drug)
Aniline hydrochloride
O-Anisidine hydrochloride
Azobenzene
B-TGDR (drug)

APPENDIX 4: (continued)

Chloramben
3-(Chloromethyl)pyridine hydrochloride
4-Chloro-m-phenylenediamine
4-Chloro-o-phenylenediamine
4-Chloro-o-toluidine hydrochloride
5-Chloro-o-toluidine
C.I. Vat yellow 4
m-Cresidine
p-Cresidine
Cupferron
p,p'-DDE
2,4-Diaminoanisole sulfate
Diaminczide
Dicofol
N,N'-Diethylthiourea
3,3'-Dimethoxybenzidine-4,4'-Diisocyanate
Direct Black 38
Direct Blue 6
Direct Brown 95
2,5-Dithiobiurea
ICRF-159 (drug)
IPD (drug)
Isophosphamide
2-Methyl-1-Nitroanthraquinone
1,5-Naphthalenediamine
Nithiazide
5-Nitro-o-Anisidine
Nitrofen
2-Nitro-p-Phenylenediamine
N-Nitrosodiphenylamine
p-Nitrosodiphenylamine
5-Nitro-o-toluidine
Phenazopyridine hydrochloride
Phenesterin (drug)
Phenoxybenzamine hydrochloride (drug)
Piperonyl sulfoxide
Pivalolactone
Sulfaliate
Tetrachlorvinphos
4,4'-Thiodianiline
O-Toluidine hydrochloride
2,4,5-Trimethylaniline
Trimethylphosphate
Trimethylthiourea

III. Chemicals designated by the staff of the Office of Toxic Materials Control as Potential Hazardous Substances.

N-Acetoxy-4-Acetamidostilbene
Acetoxyacetylaminofluorene
2-Amino-6-nitrobenzothiazole
6-Aminochrysene
Azoxymethane
5-Bromodeoxyuridine
N-Butyl(N-(4-hdroxybutyl)nitrosamine
Captafol
4 Chloro-2-methylaniline
4-Chloro-2-nitroaniline
C I Basic Violet I
C I Pigment Red 3
C I Pigment Red 23
C I Pigment Yellow 74
2,2-Dibromo-3-nitrilopropionamide
1,8-dihydroxy-4,5-dinitroanthraquinone
Dimethylaminostilbene
2,4-Dinitroaniline
Ethyloxalpha-p-chlorophenoxyisobutyrate
2,7-Fluorenylenebisacetamide
Glycidylacrylate
Glycidylmethacrylate
Glypyosphine
Granosan
4 Hydroaminoquinoline-1-oxide
Malachite Green
Manganese Sulfate

8-Methoxysporalen
Methyl(acetoxymethyl)nitrosamine
1-Methylaminoanthroquinone
Methylazoyonemethanol Acetate
3-Methylcholanthrene
5-Methylchrysene
3'-Methyl-4-dimethylaminoazobenzene
N-Methylformamide
2-methyl-1-nitro anthraquinone
N-methyl-N-nitro-N-nitrosoguanidine
4-Nitriloquinoline-1-oxide
O-Nitroanisole
Nitrosyl Chloride
Phenylglycidylether
12-O-Tetradecoylphorbate-13-acetate
Styrene Oxide
Triaminoguanidine nitrate
2,4,5-Trichlorophenoxyethanol
Triethylenemelamine

IV. Chemicals selected to be evaluated for the Air Priorities List.

Acetic anhydride
Allyl alcohol
2-Aminoethanol
p-Anisidine
p-Benzoquinone
Benzoylchloride
Biphenyl
1-Butanethiol
t-Butylamine
p-tert-Butyltoluene
Camphor
2-Chloroacetophenone
Chlorobenzene
o-Chlorobenzylidene Malonitrile
Crotonaldehyde
Diazomethane
1,3-Dichloro-5,5-dimethylhydantion
2-(Dimethylamino)ethanol
2,2'-Diethylenetriamine
Diisopropylamine
N,N-dimethylacetamide
Dimethylamine
N,N-Dimethylaniline
N,N-Dimethylformamide
1,3-Dinitrobenzene
Diphenylamine
Ethanamine
Ethanethiol
Ethylenediamine
Isopropylamine
Maleic anhydride
N-Methylanaline
Methyl iodide
p-Nitroaniline
Nitrobenzene
2-Nitropropane
m-Nitrotoluene
o-Nitrotoluene
p-Nitrotoluene
Phenyl ether
Phenylhydrazine
Phosgene
Phthalic anhydride
Propylene oxide
Pyridine
Tetranitromethane
o-Toluidine
Xylene

2.0 NIAGARA RIVER TOXICS COMMITTEE ASSESSMENT CRITERIA (NRTC)

Extracted from:

The Niagara River Toxics Committee. 1984. *Report of the Niagara River Toxics Committee.* [The Niagara River Toxics Committee, n.p.]

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6.1 Introduction

One of the principal tasks of the Niagara River Toxics Committee was to assess the significance of the types and levels of chemicals found in the Niagara River and its immediate tributaries. The eastern end of Lake Erie and the western end of Lake Ontario were included as indicative of chemicals entering and leaving the river, respectively.

Chemicals were selected from ambient monitoring reports from both lakes and the Niagara River, and included those substances found both quantitatively and qualitatively in biota, sediment, and water. Only chemicals found in ambient data were used, and not chemicals found in point source or non-point source data.

267 chemicals were identified. Of these, iron, sulphur, cholesterol, vanillin, aluminum, and silicon were excluded because they were considered to be of natural origin and minimal toxicological concern. The remaining 261 chemicals formed the universal inventory for which the NRTC was to establish some sense of priority for future monitoring and control action.

The original strategy was to sort the chemicals into groups that could be ranked according to priority: (i) chemicals requiring immediate action, (ii) chemicals requiring continuing monitoring or further investigation, and (iii) chemicals of no concern. The priority for action within groups (i) and (ii) was to be established by comparing existing environmental levels with environmental and health criteria.

The paucity of data on environmental levels and of information on the characteristics of the contaminants made it difficult to establish the three individual lists identified above. Furthermore, ranking within groups was extremely difficult due to the lack of existing criteria and major gaps in information about the nature and impact of most of the contaminants. It was decided that a screening mechanism was needed to enable the division of the large number of chemicals into smaller, more workable groups before attempting to establish a priority ranking within each of the three basic groups.

6.2 Screening Procedure

The screening mechanism that was developed to rank chemicals into groups evolved from an intensive data collection and validation procedure. All chemicals were checked to assure positive identification; all sources, both published and unpublished, were researched extensively.

Three major types of information were used in the chemical screening methodology:

1. Criteria information: These criteria were developed by several agencies and were based on the protection of aquatic life, impact on human health, etc. In each case, the most stringent criterion was used.

2. Chemical and toxicological information: Data collected on bioaccumulation and acute toxicity were used when available. Additional health parameters were introduced into the screening process through the use of the International Joint Commission (IJC) Health Effects Committee (HEC) report, and the Acute Effects Ranking (AER) system, an adaptation of the Michigan Critical Materials Register scoring methodology.

3. Environmental occurrence information: Data were submitted by the respective jurisdictions participating in the Niagara River Toxics Project.

Appendix D outlines the step-by-step procedure used in the chemical screening process, and provides a complete reference to all sources used.

6.3 Data Limitations

It should be recognized that using available information to screen a large number of chemicals has inherent problems. The Committee considered information availability in designing the screening process, and information reliability and relevance in applying information at the various decision points in the screening process. In cases where there was more than one source of information to be considered at a decision point, the information source which would classify the chemical into the group of greatest concern was applied, that is, the most stringent criterion. The policy of using the most stringent criteria may not be the most relevant on a case-by-case basis. However, it ensures that in a broad-scope screening process, the potential of a chemical to be of concern is overestimated rather than underestimated.

Because there were few data on environmental and health parameters, experimental values were sometimes used. Many of the environmental monitoring reports identified substances in terms of their compositions, either as mixtures (i.e., total PCBs), or as categories (xylene rather than the individual xylene isomers). Since the activity and chemical characteristics of most substances are dependent upon their structure as well as their composition, a range of values was sometimes available. Where this happened, the species yielding the highest AER score was chosen to represent the isomer group. The same procedure was used for mixtures such as PCBs.

As mentioned above, experimental values for toxicity and bioaccumulation were used when such information was available. Estimated Log K_{ow} (octanol/water partition coefficient data) values were used for bioaccumulation when no experimental information was available. The information was obtained from secondary sources; primary literature sources were not reviewed.

All information referenced in Appendix D is dated post-1980, although the actual environmental data may have been collected earlier. Al information was accepted as received. The material was reviewed to determine the highest and lowest documented environmental levels in the three respective media - water, sediment, and biota. Neither data quality nor the details of the monitoring surveys were considered. The highest environmental levels may represent a site specific or isolated high, and as such may not be indicative of general or widespread contamination in the Niagara study area. The relevance of the values requires case-by-case evaluation. The HEC's assessments considered exposure potential in the Great Lakes which may not necessarily reflect the exposure potential in the Niagara River.

Finally, there are several chemicals which have been detected in municipal or industrial effluents discharging (see Ch. II) into the Niagara River system that have not been reported in ambient data. These chemicals may not have been present, or may not have been looked for, or may have been present in levels too low to be detected. As a result, they were not used in this screening process. This suggests that data gaps other than those outlined in this chapter still exist.

6.4 Results

The screening process resulted in the division of the chemicals into three major groups. Group II was further subdivided into seven groups. All nine groups are listed here in order of decreasing concern.

Group I - By definition this group requires immediate attention. The chemicals are found at least once at levels equaling or exceeding criteria, or they are considered to pose risks to human health or the environment based on the HEC and AER screens. All Group I chemicals have been positively (quantitatively) identified. Each, because of its environmental levels, is recommended for source testing to determine its origin. Group I chemicals require surveillance to determine their spatial and temporal trends in each medium

The majority of Group I chemicals lack criteria for at least one environmental medium. All but five Group I chemicals have been assessed by the Health Effects Committee. These five require an HEC or similar evaluation.

Group IIA - Group IIA chemicals fall only slightly lower in priority than those in Group I. Although their environmental levels have not violated any criteria, all Group IIA chemicals have been assessed by the Health Effects Committee and are considered to represent potential health hazards. Like Group I chemicals, the chemicals in Group IIA are suggested for surveillance to determine their spatial and temporal trends to ensure that their levels remain below criteria levels. Since most Group IIA chemicals are also Group I chemicals (because of their levels in another environmental medium), these will require source testing.

Group IIB - All Group IIB chemicals have been assessed by the Health Effects Committee and have been found to be of concern. They are therefore much like Group IIA chemicals, except that their AER's have been calculated based on only one data element. More characteristics data are needed to define the significance of these chemicals. By looking at Figure D.2 in the detailed explanation of the screening process contained in Appendix D, the similarity between Group IIA and IIB is more obvious. This similarity also exists between Groups IIC and IID, Groups IIE and IIF, and Groups III and IIG. The groups on the left side of the figure have less information available to make a categorical statement based on the AER. In other words, more characteristics data are required for groups on the left side of Figure D.2.

Group IIC - All chemicals in this group require an evaluation by the Health Effects Committee. Only a few of the Group IIC chemicals have information relating to bioaccumulation (BCF). In general, these chemicals require attention to their characteristics, criteria development, and assessment and warrant some limited monitoring.

Group IID - As discussed under Group IIB, Groups IIC and IID are very similar. Group IID does, however, require more attention to its characteristics as there were only enough data available to calculate the AER based on one data element. Like Group IIC, no Group IID chemicals have been evaluated by the Health Effects Committee. A significant number of Group IID chemicals have only been identified qualitatively. They require additional monitoring to confirm their existence.

Group IIE - Although Group IIE chemicals have been found to be of no concern by the Health Effects Committee, their AER scores indicate that a problem could exist. Since half of these chemicals are also Group I chemicals (in another medium), some attention should be paid to them during environmental monitoring. Development of criteria should also be considered.

Group IIF - As the analogue to Group IIE, Group IIF chemicals also require attention to the development of criteria and, to a limited extent, to monitoring. The bulk of the effort to address information gaps for chemicals in this group must be placed on their characteristics so that a more thorough assessment can be made of the significance of these chemicals.

Group IIG - Group IIG chemicals are considered to require little attention. They have been judged by the Health Effects Committee to be of no concern. Based on their AER scores, they are not potential threats, although their AER's were calculated using only one data element. Some effort should be devoted to obtaining additional characteristics data for these chemicals.

Group III - Group III chemicals require very little attention. Their HEC evaluations and AER scores are such that priority need not be given to these chemicals.

6.5 Future Action

Even though general statements can be made about each group, each chemical within that group is unique, and considerable variability between chemicals can occur within a group. Some of the factors contributing to this intergroup variability are a chemical's AER ranking and HEC evaluation, whether the chemical was found qualitatively or quantitatively, the medium in which was isolated, when it was identified, how often it was identified, and in which it geographic locations. Because of these varied and uncontrollable influences, it was not possible to rank the chemicals within each group in order of priority. It was therefore decided that, for each of the nine groups, specific recommendations should be made for each chemical. Table 6.1 identifies areas where environmental monitoring and research is required to fill some of the gaps in the current data base.

It is possible for any one chemical to be found at varying concentrations in each of the three environmental media (water, biota, sediment). This preference is influenced by a number of factors, for example the chemical's characteristics and method of entry into the environment. The sampling and analytical methods may also influence the relative proportion of the chemcials detailed in each of the three media. Therefore, it is possible for a chemical to be of major concern in one medium but represent no risk at all in another. For that reason some chemicals appear in more than one group in Table 6.1. By making this type of distinction between media, it becomes easier to determine what specific action is needed for each chemical. The amount of attention, and therefore the time and cost necessary to address each chemical, can be more readily determined.

Each chemical in Table 6.1 is followed by a letter (either S, W, or B) to indicate to which medium that particular group assignment applies. For example, in Group III benzene is listed followed by an S. This means that the benzene contamination of sediment is considered to be minimal and therefore it was assigned to Group III. Benzene, however, was also isolated in water. Its level in water was such that it is considered to be a major priority; therefore, benzene also appears as a Group I chemical. Many chemicals appear in only one group. To reflect the fact that dual group assignments can occur, Table 6.1 contains notes which cross reference one group with another. As an example, benzene in Group I is referenced to Group III and vice versa.

The remaining columns in Table 6.1 contain the recommended actions for monitoring, characteristics, and assessment activities. The monitoring column contains four sub-headings; source, confirmation, trend, and media. An X in the source column indicates point and non-point source testing is warranted to determine the chemical's origin. All Group I chemicals require source testing.

Chemicals found qualitatively only in a particular medium are indicated in the confirmation column with the letter symbolizing the medium in which they were identified. These chemicals require further monitoring to confirm their presence in that particular medium.

Chemicals considered to be of such importance that their environmental trends should be determined through a regular surveillance program are marked in the trend column. All Group I and Group IIA chemicals fall into this category. Group IIA chemicals were included because, although their environmental levels are currently below criteria, they are considered by the HEC to represent potential health hazards. As such, it is important to determine whether their levels are increasing, and thereby raise them to Group I status.

TABLE 6.1

CHEMICAL GROUP
ASSIGNMENTS AND REQUIREMENTS FOR ACTION

CHEMICAL GROUP	MONITORING				CHARACTERISTICS				ASSESSMENT		
	Source	Conf	Trend	Media	LC50	LD50	Log Kow	BCF	Crit	HEC	
GROUP I											
Aldrin (S)	X		S	W,B,S					S		
Antimony (W)	X		W	W,B,S		X	X	X	S	X	See Group IID
Arsenic (S)	X		W,B,S	W,B,S				X		X	See Group IIA
Benzene (W)	X		W	W,B,S					S		See Group III
Benzo(B)fluoranthene (W)	X		W	W,B,S	X	X		X	S		See Group IIB
Benzo(K)fluoranthene (W)	X		W	W,B,S	X	X		X	S		See Group IIF
Benz(A)anthracene (W)	X		W	W,B,S	X	X			S		See Group IIF
Benz(A)pyrene (S,W)	X		W,S	W,B,S	X						
Beryllium (W)	X		W	W,B,S		X	X	X	S	X	See Group IID
BHC (α) (W)	X		W,B,S	W,B,S				X	B,S		See Group IIA
Bis(2-ethylhexyl) phthalate (S,W)	X		W,S	W,B,S		X			S		
Cadmium (B,S,W)	X		W,B,S	W,B,S					B		
Carbon tetrachloride (W)	X		W	W,B,S							
Chlordane (S,W)	X		W,B,S	W,B,S					S		See Group IIA
Chloroform (W)	X		W,S	W,B,S				X	S		See Group IIA
Chromium (S,W,)	X		W,B,S	W,B,S			X		B		See Group IIA
Chrysene (W)	X		W	W,B,S					S		See Group IIB
Copper (S,W)	X		W,S	W,B,S		X	X	X			See Group IIF
Cyanide (S,W)	X		W,S	W,B,S		X	X	X		X	
DDD (p,p) (S,W)	X		W,B,S	W,B,S					S		See Group IIA
DDE (S,W)	X		W,B,S	W,B,S	X				S		See Group IIA
DDT (p,p) (S,W)	X		W,B,S	W,B,S					S		See Group IIA
1,2 Dichloroethane (W)	X		W	W,B,S				X			
Dieldrin (S,W)	X		W,B,S	W,B,S					S		See Group IIA
Dioctyl phthalate (W)	X		W	W,B,S	X				S	X	See Group IIC
Endosulphan (S,W)	X		W,B,S	W,B,S					S		See Group IIA
Endrin (S,W)	X		W,B,S	W,B,S					S		See Group IIA
Fluoranthene (W)	X		W	W,B,S				X	S		See Group III
Heptachlor (S)	X		B,S	W,B,S					S		See Group IIA
Heptachlor epoxide (S,W)	X		W,B,S	W,B,S	X				S		See Group IIA
Hexachlorobenzene (B,S)	X		W,B,S	W,B,S	X				B,S		See Group IIA
Hexachlorobutadiene (B,S,W)	X		W,B,S	W,B,S					B,S		
Lead (S,W)	X		W,B,S	W,B,S		X	X				See Group IIA
Lindane (S,W)	X		W,B,S	W,B,S					S		See Group IIA
Mercury (S,W)	X		W,S	W,B,S		X	X				

TABLE 6.1 (Continued)

CHEMICAL GROUP	MONITORING				CHARACTERISTICS				ASSESSMENT		
	Source	Cont	Trend	Media	LC50	LD50	Log Kow	BCF	Crit	HFC	
GROUP I (Cont'd)											
Methoxychlor (B,S)	X		B,S	W,B,S		X			B,S		
Methylene chloride (W)	X		W	W,B,S				X	S		See Group
Mirex (W)	X		W,B,S	W,B,S					S		See Group
Nickel (S,W)	X		W,B,S	W,B,S		X	X		B		See Group
Pentachlorobiphenyl (S)	X		S	W,B,S		X					
Pentachlorophenol (B,W)	X		W,B	W,B,S					B		
Phenol (W)	X		W,B	W,B,S				X	S		See Group
Polychlorinated Biphenyl Arochlor 1242 (B,S)	X		B,S	W,B,S							
Polychlorinated Biphenyl Arochlor 1254 (S)	X		S	W,B,S							
Polychlorinated Biphenyl Arochlor 1260 (W)	X		W	W,B,S							
Pyrene (W)	X		W	W,B,S	X			X	S		See Group
Selenium (W)	X		W,S	W,B,S		X	X		S		See Group
Silver (S,W)	X		W,S	W,B,S		X	X				
TCDD (B,W)	X		W,B	W,B,S		X					
Tetrachlorobiphenyl (S)	X		S	W,B,S		X					
Tetrachloroethene (W)	X		W,S	W,B,S					S		See Grou
Trichlorobiphenyl (S).	X		S	W,B,S		X					
2,4,5-Trichlorophenol (B)	X		W,B	W,B,S					B		See Grou
2,4,6-Trichlorophenol (B,S)	X		B,S	W,B,S		X		X	B,S		
Zinc (S,W)	X		W,S	W,B,S		X	X		B		See Grou
GROUP IIA											
Aniline (S)			S	W,B,S		X		X	S		
Arsenic (B,W)	X		W,B,S	W,B,S				X			See Gro
BHC (S)			S	W,B,S				X	S		
BHC (α) (B)	X		W,B,S	W,B,S				X	B,S		See Gro
Bromoform (W)			W	W,B,S							
Chlordane (B)	X		W,B,S	W,B,S					S		See Gro
Chlorodibromomethane (S,W)			W,S	W,B,S	X			X	S		
Chloroform (S)	X		W,S	W,B,S				X	S		See Gr
Chloronaphthalene (S,W)	W		W,S	W,B,S	X			X	S		
Chromium (B)	X		W,B,S	W,B,S			X		B		See Gr
2,4-D (W)			W	W,B,S							
DDD (p,p) (B)	X		W,B,S	W,B,S					S		See Gr

TABLE 6.1 (Continued)

CHEMICAL GROUP	MONITORING				CHARACTERISTICS				ASSESSMENT	
	Source	Conf	Trend	Media	LC50	LD50	Log Kow	BCF	Crit	HEC
GROUP IIA (Cont'd)										
DDE (B)	X		W,B,S	W,B,S	X				S	See Group I
DDT (B)	X		W,B,S	W,B,S					S	See Group I
1,2-Dichlorobenzene (S,W)			W,S	W,B,S		X			S	
1,3-Dichlorobenzene (S,W)			W,S	W,B,S		X		S		
1,4-Dichlorobenzene (B,S,W)			W,B,S	W,B,S		X			B,S	
1,2-Dichloroethylene (S)			S	W,B,S		X		X	S	
Dieldrin (B)	X		W,B,S	W,B,S					S	See Group I
Diphenylamine (S)			S	W,B,S	X				S	
Endosulphan (B)	X		W,B,S	W,B,S					S	See Group I
Endrin (B)	X		W,B,S	W,B,S					S	See Group I
Ethylbenzene (S,W)			W,S	W,B,S				X	S	
Heptachlor (B)	X		B,S	W,B,S					S	See Group I
Heptachlor epoxide (B)	X		W,B,S	W,B,S	X				S	See Group I
Hexachlorobenzene (W)	X		W,B,S	W,B,S	X				B,S	See Group I
Lead (B)	X		W,B,S	W,B,S		X	X			See Group I
Lindane (B)	X		W,B,S	W,B,S					S	See Group I
Mirex (B,S)	X		W,B,S	W,B,S					S	See Group I
Nickel (B)	X		W,B,S	W,B,S		X	X		B	See Group I
Phenol (S)	X		W,S	W,B,S				X	S	See Group I
Selenium (S)	X		W,S	W,B,S					S	See Group I
Silvex (W)			W	W,B,S				X		
Styrene (W)			W	W,B,S				X	W	
2,4,5-T (W)			W	W,B,S				X	W	
Tetrachloroethene (S)	X		W,S	W,B,S					S	See Group I
Tribromomethane (S)			S	W,B,S		X		X	S	
Trichloroethene (W)			W	W,B,S		X		X		
Trichlorophenol (W)	X		W,B	W,B,S					B	See Group I
GROUP IIB										
Benzo(B)fluoranthene (S)	X		W	W,B,S	X	X		X	S	See Group I
Chrysene (S)	X		W	W,B,S	X	X		X	S	See Group I
Dibenz(A,H)anthracene (S,W)				B	X	X		X	W,S	
Dichlorobromomethane (W)				B,S	X	X		X		
Dichloronaphthalene (S,W)		W		W,B	X	X			S	
Trichloronaphthalene (S)					X	X			S	

TABLE 6.1 (Continued)

CHEMICAL GROUP	MONITORING				CHARACTERISTICS				ASSESSMENT		
	Source	Conf	Trend	Media	LC50	LD50	Log Kow	BCF	Crit	HEC	
GROUP IIC											
Benzaldehyde (B,S,W)								X	H,B,S	X	
BHC (β) (B,W)				S		X		X	B	X	
Benzene sulphonamide (W)				B,S	X			X	W	X	
Butanal (W)				B,S				X	W	X	
Butanol (W)				B,S				X	W	X	
Butylphenol (T) (W)		W		W,B,S	X				W	X	
Chlorobenzene (S,W)				B					S	X	
Chlorotoluene (S,W)				B				X	W,S	X	
DCPA (B,S)						X		X	B,S	X	
DDT-(o,p) (S)					X			X	S	X	
1,1-Dichloroethane (S)								X	S	X	
Dichlorophenol (W)				B,S				X	W	X	
2,4-Dichluro 4 phenoxybutyric acid (S)		S		S	X			X	S	X	
Dichloropropane (W)		W		W,B,S				X		X	
1,2-Dichloropropane (S)								X	S	X	
Dichloropropene (W)		W		W,B,S	X			X		X	
2,6-Dichlorotoluene (B,S,W)		B		B	X				W,B,S	X	
Diethyl disulphide (W)		W		W,B,S	X			X	W	X	
Diethyl phthalate (S)								X	S	X	
Dimethylheptadienone (S)					X				S	X	
Dimethyl phthalate (S)								X	S	X	
Dinitroanisole (S)					X			X	S	X	
Dioctyl phthalate (S)	X		W	W,B,S	X				S	X	See Group 1
1,2-Diphenylhydrazine (S)						X		X	S	X	
Hexanal (W)				B,S	X			X	W	X	
Hexenone (W)				B,S	X			X	W	X	
Isobutanal (W)		W		W,B,S	X			X	W	X	
Isobutanol (W)		W		W,B,S				X	W	X	
Isophorone (B)				S		X		X	B	X	
Manganese (S)						X	X		S	X	
Methylcoumarin (S)					X			X	S	X	
Methylfuran (W)		W		W,B,S	X			X	W	X	
Methylnaphthalene (B,S,W)						X			W,B,S	X	
Methylpentene (W)		W		W,B,S		X		X	W	X	
Methyl pivalate (S)					X				S	X	
N Nitrosodiphenylamine (S)						X		X	S	X	
Octachlorostyrene (B,S)					X				B,S	X	
Pentachloroanisole (W)				B,S	X			X	W	X	

TABLE 6.1 (Continued)

CHEMICAL GROUP	MONITORING				CHARACTERISTICS				ASSESSMENT		
	Source	Conf	Trend	Media	LC50	LD50	Log Kow	BCF	Crit	HEC	
GROUP IIC (Cont'd)											
Pentachlorobenzene (B,S,W)						X			B,S	X	
Phenothiazine (S,W)				B	X			X	W,S	X	
Tetrachlorobenzene (B)				S				X	B	X	
1,2,3,4-Tetrachlorobenzene (S,W)				B				X	S	X	
1,2,4,5-Tetrachlorobenzene (S,W)				B				X	S	X	
1,1,2,2-Tetrachloroethane (S,W)				B		X		X	S	X	
2,3,4,6-Tetrachlorophenol (B)				S		X		X	B	X	
Tetrahydrofuran (W)				B,S		X		X		X	
(Tetramethylbutyl)phenol (W)				B,S	X			X	W	X	
Trichlorobenzene (B)				S					B	X	
1,2,3-Trichlorobenzene (S,W)				B		X		X	S	X	
1,2,4-Trichlorobenzene (S,W)				B					S	X	
1,3,5-Trichlorobenzene (S,W)				B		X		X	S	X	
2,4,5-Trichlorotoluene (S,W)				B	X			X	W,S	X	
Trimethylbenzene (W)		W		W,B,S	X			X		X	
2,4-Xylenol (S)						X		X		X	
GROUP IID											
Acenaphthylene (S)					X	X		X	S	X	
1-Aminonaphthalene (S)					X	X		X	S	X	
Antimony (S)	X		W	W,B,S		X	X	X	S	X	See Group I
Barium (S,W)				B		X	X	X	S	X	
Benzo(G,H,I)perylene (S,W)				B	X	X		X	W,S	X	
Benzo(E)pyrene (S)					X	X		X	S	X	
Benzyl benzoate (S)					X	X		X	S	X	
Benzylidene-4,4'-bis(N,N-dimethylaniline (S)					X	X		X	S	X	
N-Benzyl-N-ethylaniline (S)					X	X		X	S	X	
Beryllium (S)	X		W	W,B,S		X	X	X	S	X	See Group I
Chloroanthracene (W)		W		W,B,S	X	X			W	X	
Chlorodibromoethane (W)				B,S	X	X			W	X	
Chloro(difluorochloromethyl) benzene (W)		W		W,B,S	X	X			W	X	
Chlorohydroxybenzophenone (S,W)		W		W,B	X	X			W,S	X	
Chlorohydroxyphenothiazine (W)		W		W,B,S	X	X			W	X	
Chloromethoxybenzophenone (W)		W		W,B,S	X	X			W	X	
Chloromethylbis(phenylmethyl) benzene (S,W)		W		W,B	X	X			W,S	X	

TABLE 6.1 (Continued)

CHEMICAL GROUP	MONITORING				CHARACTERISTICS				ASSESSMENT	
	Source	Conf	Trend	Media	LC50	LD50	Log Kow	BCF	Crit	HEC
GROUP IID (Cont'd)										
Chloromethyldiphenylmethane (S,W)		W		W,B	X	X			W,S	X
Chloronitrobenzene (S)					X	X	X		S	X
(Chlorophenyl)cyclohexene (S)					X	X	X		S	X
2-Chloro(trifluoromethyl) benzene (B)				S	X	X	X		B	X
3-Chloro(trifluoromethyl) benzene (W)				B,S	X	X	X		W	X
4-Chloro(trifluoromethyl) benzene (B)				S	X	X	X		B	X
2,4-Decadienal (B)				S	X	X	X		B	X
Dibenzofuran (S)					X	X	X		S	X
Dibromomethane (W)				B,S	X	X	X			X
Dichloroanthracene (W)		W		W,B,S	X	X	X		W	X
Dichlorobromoethane (W)				B,S	X	X			W	X
Dichloromethylbis(phenylmethyl) benzene (S,W)		W		W,B	X	X			W,S	X
Dichloromethyldiphenyl-methane (S,W)		W		W,B	X	X			W,S	X
Dichlorophenanthrene (S)					X	X		X	S	X
2,4-Dichloro-2-phenoxyethanol (W)		W		W,B,S	X	X			W	X
Dichloroquinone (S)					X	X		X	S	X
Dichloro(trifluoromethyl) benzene (W)		W		W,B,S	X	X			W	X
2,3-Dichloro(trifluoromethyl) benzene (B)				S	X	X			B	X
2,4-Dichloro(trifluoromethyl) benzene (B)				S	X	X		X	B	X
3,4-Dichloro(trifluoromethyl) benzene (B)				S	X	X		X	B	X
Dichloro(trifluoromethyl) benzophenone (S,W)		W		W,B	X	X		X	W,S	X
Dicyclohexyl phthalate (S)					X	X		X	S	X
Diethylcyclohexanone (S)					X	X		X	S	X
4-(Dimethylamino)benzophenone (S)					X	X		X	S	X
Dimethyl disulphide (W)				B,S	X	X		X	W	X
Dimethylphenanthrene (S)					X	X			S	X
N,N-Dimethyl-2-propenoamide (W)				B,S	X	X		X	W	X
Diphenylcyclohexane (S)					X	X			S	X

TABLE 6.1 (Continued)

CHEMICAL GROUP	MONITORING				CHARACTERISTICS				ASSESSMENT	
	Source	Conf	Trend	Media	LC50	LD50	Log Kow	BCF	Crit	HEC
GROUP IID (Cont'd)										
Diphenyldifluoromethane (W)		W		W,B,S	X	X		X	W	X
Di-t-butylquinone (S)					X	X		X	S	X
3-Ethyl-4 methylmaleic anhydride (S)					X	X		X	S	X
Ethyltoluene (W)		W		W,B,S	X	X		X	W	X
(2-Fluoroethyl) pentachlorobenzene (S)					X	X		X	S	X
Furan (W)		W		W,B,S	X	X		X	W	X
Heptachlorodibenzofuran (S)					X	X	X		S	X
Heptachlorotoluene (S)					X	X	X		S	X
Hexachlorodibenzofuran (S)					X	X	X		S	X
Hexachlorotoluene (S,W)		W		W,B	X	X			W,S	X
4-Hydroxybenzaldehyde (B)				S	X	X	X		B	X
Indeno(1,2,3-CD)pyrene (S)					X	X	X		S	X
2-Methylbutanoic acid (B)				S	X	X	X		B	X
Methyldibenzofuran (S)					X	X	X		S	X
Methylene 4,4'-bis (N,N dimethylaniline) (S)					X	X	X		S	X
Methylfluorene (S)		S		S	X	X		X	S	X
5-Methyl-3-hexen-2-one (B)				S	X	X		X	B	X
o Methyloxime-3 pentanone (S)					X	X		X	S	X
Methylpyrene (S)					X	X		X	S	X
3-Nonen-2-one (B)				S	X	X		X	B	X
Octachlorodibenzofuran (S)					X	X		X	S	X
Pentachlorobiphenylene (S)					X	X		X	S	X
Pentachlorocarbazole (S)					X	X		X	S	X
Pentachlorodibenzofuran (S)					X	X		X	S	X
Pentachlorodifluoronaphthalene (S)					X	X		X	S	X
Pentachlorofluorene (S)					X	X		X	S	X
Pentachloromethylbis (phenylmethyl)benzene (S,W)				B	X	X			W,S	X
Pentachlorophenylfluoromethyl ether (S)					X	X		X	S	X
Pentachlorotoluene (S,W)				B	X	X		X	W,S	X
Phenylacetaldehyde (B)				S	X	X		X	B	X
Phenylacetic acid (B)				S	X	X		X	B	X
Phenylnaphthalene (S)					X	X		X	S	X
Piperidinone (B)				S	X	X		X	B	X

TABLE 6.1 (Continued)

CHEMICAL GROUP	MONITORING				CHARACTERISTICS				ASSESSMENT		
	Source	Conf	Trend	Media	LC50	LD50	Log Kow	BCF	Crit	HEC	
GROUP IID (Cont'd)											
Tetrachlorocarbazole (S)					X	X		X	S	X	
Tetrachlorodibenzofuran (S)					X	X		X	S	X	
Tetrachloromethylbis(phenylmethyl) benzene (S,W)				B	X	X			W,S	X	
Tetrachlorophenanthrene (S)					X	X		X	S	X	
Tetrachlorotoluene (S,W)				B	X	X		X	W,S	X	
N,N,N',N'-Tetramethylbenzidene (S)					X	X		X	S	X	
Thallium (S)						X	X	X	S	X	
Trichloroanthracene (W)				B,S	X	X			W	X	
Trichlorodiphenylmethane (W)				B,S	X	X		X	W	X	
Trichloromethylbis(phenylmethyl) benzene (S,W)				B	X	X			W,S	X	
Trichlorophenanthrene (S)					X	X		X	S	X	
(Trifluoromethyl)benzene (W)				B,S	X	X		X	W	X	
Trimethylbiphenyl (B)				S	X	X		X	B	X	
Trimethylphenanthrene (S)					X	X		X	S	X	
3A,6,6-Trimethyl-3A,4,5,6-tetrahydro-2-coumaranone (S)					X	X		X	S	X	
Zytron (B,S)					X	X		X	B,S	X	
GROUP IIE											
Di n-butyl phthalate (S,W)				B		X			S		
Diethylbenzene (W)				B,S					W		
Fluoranthene (S)	X		W	W,B,S				X			See Group I
Methylene chloride (S)	X		W	W,B,S				X			See Group I
Methyl phenanthrene (S)						X		X	S		
Pyrene (S)	X		W	W,B,S	X			X			See Group I
1,1,1-Trichloroethane (S,W)				B		X		X	S		
Zinc (B)	X		W,S	W,B,S		X	X		B		See Group I
GROUP IIF											
Benz(A)anthracene (S)	X		W	W,B,S	X	X			S		See Group I
Benzo(K)Fluoranthene (S)	X		W	W,B,S	X	X		X			See Group I
Benzofluorene (S)					X	X		X	S		
Copper (B)	X		W,S	W,B,S		X	X	X			See Group I
Coronene (S)					X	X		X	S		

TABLE 6.1 (Continued)

CHEMICAL GROUP	MONITORING				CHARACTERISTICS				ASSESSMENT	
	Source	Conf	Trend	Media	LC50	LD50	Log Kow	BCF	Crit	HEC
GROUP IIF (Cont'd)										
Methylanthracene (S)					X		X		X	S
Methyl palmitate (S)					X		X		X	S
Perylene (S)					X		X		X	S
Phenanthrene (S,W)				B	X	X			W,S	
GROUP IIG										
Anthracene (S,W)		W		W,B	X	X		X	W,S	
Dimethyl adipate (S)						X	X		X	S
Fluorene (S,W)				B	X	X		X	W,S	
Fluorotrichloromethane (S)						X	X		X	S
Hexane (W)				B,S	X	X		X	W	
GROUP III										
Acenaphthene (S)						X		X	S	
Acetone (W)				B,S		X		X	W	
Benzene (S)	X		W	W,B,S					S	See Group I
Benzothiazole (S,W)				B	X			X	W,S	
Benzyl alcohol (S)								X	S	
Benzylbutyl phthalate (S)									S	
Biphenyl (S,W)		W		W,B					W,S	
Butanol (T) (W)				B,S		X		X	W	
2 Butanone (W)				B,S		X		X	W	
Carbon disulphide (W)				B,S		X		X	W	
Cumene (W)				B,S				X	W	
Diethylether (W)				B,S				X	W	
Dimethylaniline (W)				B,S	X			X	W	
Naphthalene (S,W)				B					S	
Pentane (W)				B,S				X	W	
Propanol (W)				B,S		X		X	W	
Toluene (S,W)				B					S	
Trichlorotrifluoroethane (W)		W		W,B,S	X			X	W	
m Xylene (S)								X	S	
o Xylene (W)								X		

The media column indicates the specific medium in which each chemical should be sampled. All chemicals referenced to a particular medium (sediment, water, biota) in the confirmation and trend columns are also referenced in the media column. In addition to this, chemicals found in a lower concentrating medium, but for which no data exist for a higher concentrating medium, are also referenced in the media column. For example, biphenyl is a Group III chemical found in sediment and water. No data are available for biota. Since biota and sediment contaminant levels are generally higher than water levels, it would seem prudent to check biota for biphenyl to determine whether it would be of concern in this medium.

The four sub-headings (LC50, LD50, Log K_{ow}, BCF) under the characteristics column are self explanatory. Xs are used to indicate where data are missing.

The assessment column contains two sub-headings; criteria and HEC. The criteria column indicates the media, for those in which the chemical was identified, for which no criteria are available. An X in the HEC column indicates that either the chemical has not been considered by the HEC, or there was insufficient data for the HEC to conduct an assessment.

Other recommendations which arose from classifying these chemicals into groups are incorporated into the previous section (6.4).

3.0 WORK OF THE PRIORITY LIST WORKING GROUP, ONTARIO MINISTRY OF THE ENVIRONMENT

CanTox Inc., SENES Consultants Ltd. and the Ontario Ministry of the Environment. Priority List Working Group. *Part I Report: Vector Scoring System for the Prioritization of Chemical Contaminants*, Draft Report [unpublished report dated 1986].

ONTARIO MINISTRY OF THE ENVIRONMENT SCREEN III PARAMETERS

INTRODUCTION

The following generally accepted parameters have been developed to determine the concern level for a chemical in the environment. These parameters are a subgroups of the parameters in a methodology, presently being developed for the Ministry of the Environment, for assessing the relative environmental hazards of chemical contaminants. The magnitude of the score assigned to each parameter reflects the level of concern arising from that property of a chemical.

1. Environmental Behaviour Parameters

Range of scores: 0-10 for all parameters a. to c. except Environmental Transport which is 0-4.

a) Environmental Transport
b) Environmental Persistence
c) Bioaccumulation

2. Toxicity Parameters

Range of scores: 0-10 for all parameters a. to g.

a) Acute Lethality
b) Sub-Lethal Effects on Non-Mammalian Animals
c) Sub-Lethal Effects on Plants
d) Sub-Lethal Effects on Mammals
e) Teratogenicity
f) Genotoxicity/Mutagenicity
g) Carcinogenicity

In addition to the numerical value assigned to a parameter, various symbols are used to indicate special concerns regarding the source of, or confidence in, the underlying data:

- If the data required are not available, an asterisk (*) is assigned to that parameter rather than a numerical score.

- If the data used are questionable (e.g., data lacking in documentation, data derived with outdated methods), a score is assigned to the parameter, but it is "tagged" with a question mark (?) to indicate doubt regarding the confidence in the data.

- If the data used in the assignment of a parameter score is "limited", the score for that parameter is "tagged" with an "L". This indicates that a score was assigned, but due to the nature of the readliy available data, confidence in the score was less than if a more comprehensive data set had been used. In many instances, additional data would either remove the "L" designation and confirm the score, or result in a higher score.

  "L" was also used if the scoring criteria were not completely met (e.g. in the case of teratogenicity at exposure levels of greater than 1000 mg/kg/day, no criteria fits this so a score of "0L" would be assigned).

- If the data used are perceived as representing a worst-case scenario (e.g., toxicity data from intravenous administration), the score for that parameter is "tagged" with an exclamation mark (!).

- If the data used in the assignment of a parameter score are estimated from environmental modelling techniques or structure-activity relationships, the score for that parameter is "tagged" with a superscript "e".

These "tags" may be taken into consideration when the chemical is reviewed.

PARAMETERS

1. Environmental Behaviour Parameters

(a) ENVIRONMENTAL TRANSPORT

Rationale

This parameter describes the transport of chemicals between environmental media. The environmental transport of a chemical is an important factor in evaluating its potential environmental and health hazards. Inter-media transport can be observed during field studies or by undertaking microcosm studies in a laboratory, but relatively few substances have been studied using such techniques. One way to estimate the environmental transport characteristics of a chemical is to use a simple mathematical model such as the Fugacity Level II model.

The Fugacity Level II model estimates the equilibrium distribution of a chemical released to the environment. The environmental media considered are air, water, soil, sediment and biota. The model requires information about both the chemical and receiving environment. The necessary chemical properties are molecular weight, solubility, vapour pressure, and the octanol-water partition coefficient. Approximate constants for key environmental processes and an estimate of overall environmental half-life are also needed. Each of the environmental media must be characterized. These characteristics are influenced by the size of the area being considered (MacKay and Paterson, 1981).

Scoring Criteria

The criteria for this parameter use results from environmental models.

In addition, there are criteria for substances that are largely associated with fine particles (generally less than 10 um in size). Examples are fine particles associated with incinerator processes.

The scoring criteria for this parameter are as follows:

PARAMETER SCORE	CRITERIA
4	At least two media other than the receiving medium, each containing more than 20% of the chemical released; OR most of the chemical is associated with fine particles when released into the environment.
3	One or more media other than the receiving medium, each contain 10% to 20% of the chemical released;
2	One or more media other than the receiving medium, each contain 5% to 10% of the chemical released;
0	Less than 5% of the chemical released partitions into media other than the receiving medium;

Suggested Information Sources

Lyman *et al.*, 1982 -

A comprehensive reference of published values and estimation methods for various physical and chemical properties.

Verschueren, 1983 -

A handbook of environmental data for organic chemicals.

ENVIROFATE and ISHOW databases -

Contain solubility, vapour pressure, partition coefficients for many chemicals.

ICF Inc., 1985 -

Contains tabulations of physical, chemical and fate data for many organic substances and elements.

Mills *et al.*, 1982 -

A compilation of physical, chemical and fate data for many organic substances.

Mackay and Shiu, 1981 -

A compilation of physical and chemical parameters for organic substances.

Kenaga and Goring, 1980 -

A compilation of solubility, sorption and K_{ow} data.

Clayton and Clayton, 1981 -

A comprehensive reference of information on industrial chemicals.

Karickhoff, 1984 -

Discussion of sorption processes in general and K_{ow}/K_{oc} values in particular.

Amoore and Hautala, 1983 -

Information on volatilities of industrial chemicals.

Neely and Blau, 1985 -

Contains physical, chemical and fate data and estimation methods.

(b) ENVIRONMENTAL PERSISTENCE

Rationale

This parameter describes the tendency for a chemical to persist in the environment. Substances in the environment can be subjected to a variety of processes including sorption, oxidation, hydrolysis, photodegradation and biodegradation. The net result of such processes may be expressed as the overall persistence of a substance in the environment. When quantified, persistence is usually expressed as the length of time required for one-half of the original amount of a substance to be degraded. It is analogous to parameters which may be presented as "rate of loss in natural systems", "overall half-life", or "50% recovery time". It is also similar to the "persistence" parameter calculated by fugacity models.

Half-lives of chemicals may vary from seconds to thousands of years (ICF Inc., 1985). Short half-lives generally indicate a lower level of concern. For example, environmental releases of substances with half-lives of less than a few days often will not result in significant accumulation in the environment. Conversely, those with half-lives of several months or longer can lead to substantial exposure or accumulation in the food chain.

Scoring Criteria

The criteria for this parameter are based on half-life values or on general descriptors of persistence. If scores can be assigned using both quantitative and qualitative criteria, the higher score should be used.

If half-life data are available, they will usually pertain to specific media as opposed to general environmental persistence. This information provides an indication of levels of concern regarding specific media. In such cases, it is recommended that the media providing the highest score be used.

If persistence values have not been reported and cannot be estimated by using environmental models, other types of information may offer guidance in developing a score for this parameter. For example, structure-activity relationships (SARs) may provide general indications of persistence for relatively unknown substances structurally similar to more familiar substances. To assess the potential biodegradability of substances in wastewater treatment plants, test methods such as the static-culture-flask and shaker-flask techniques have been used (for example, see Tabak et al., 1981). The results of these tests in general show good agreement with published work on biodegradability. Substances not degraded under test conditions cannot be presumed to be immune to microbial action in the environment. Accordingly, scores derived from SARs or biodegradability tests should be tagged with a superscript "e", a question mark, or exclamation mark as appropriate.

PARAMETER SCORE	CRITERIA
10	Half-life greater than 100 days; OR designated as very persistent
7	Half-life of more than 50 but less than or equal to 100 days; OR designated as moderately persistent.
4	Half-life of more than 10 but less than or equal to 50 days; OR designated as slightly persistent.
0	Half-life of less than or equal to 10 days; OR designated as not persistent

Suggested Information Sources

ICF Inc., 1985 -
Includes compilation of half-lives in several media for organic substances.

Mills et al., 1982 -
Includes compilation of half-lives in aquatic media for organic substances.

Verschueren, 1983 -
Includes half-lives and biodegradability test results for organic substances.

NRCC - National Research Council of Canada Associate Committee on Scientific Criteria for Environmental Quality - These publications include data on biodegradability for specific substances.

ENVIROFATE database -
Contains data on biodegradation rates for chemicals released to the environment.

Tabak et al., 1981 -
Includes results of biodegradability studies for more than 100 organic substances.

(c) BIOACCUMULATION

Rationale

This parameter describes the tendency for a substance to accumulate in biological systems. In the current context, the term bioaccumulation is intended to convey the ability of a substance to accumulate in the tissues of organisms. The tendency for certain groups or classes of chemicals to bioaccumulate is well documented. This process has also been referred to as bioconcentration or biomagnification and some authors have assigned various distinct definitions to these terms but for purposes of this assessment those differences are relatively unimportant.

One of the parameters frequently used to express bioaccumulation is the bioconcentration factor (BCF). Most BCF values pertain to fish or other aquatic organisms and are calculated as the ratio of the concentration of a substance in the organism (or some specific tissue) on a wet weight basis to the concentration of the substance in the water at steady state (Veith et al., 1980). For organic substances, values of BCF range from about 1 to more than 1,000,000 (Lyman et al., 1982).

Bioaccumulation factors have also been determined for some terrestrial vertebrates but these data are less abundant and more difficult to locate than those for aquatic organisms. It is recommended for this assessment that data collection efforts first focus on BCF values for aquatic organisms.

The tendency of substances to bioaccumulate in tissue frequently has been related to hydrophobicity or lipophilicity (Veith et al, 1980). As a result, various regression equations have been suggested for predicting BCF values for aquatic organisms based on the octanol-water partition coefficient (K_{ow}) and other physico-chemical properties. To date, those that use K_{ow} values have been the most widely investigated and most successful (Lyman et al., 1982; Geyer et al., 1984).

Scoring Criteria

Scoring criteria for this parameter are defined in terms of either BCF or log K_{ow}. The correlation between the two sets of criteria is based upon the following relationship developed from experimental data on 84 chemicals (Veith et al., 1980):

$$\log BCF = 0.76 \log K_{ow} - 0.23$$

Other equations have been developed based upon various groups of chemicals. If an equation is available that is more directly applicable to a substance being evaluated, that equation can be used.

The bioaccumulation of compounds with relatively high K_{ow} values is influenced by the degree to which a compound dissociates in water. Equations for estimating bioaccumulation that include a dissociation term have not been reported. For this parameter, dissociation has not been considered in the determination of scores. This should tend to produce somewhat higher scores than warranted for some organic substances. BCF values can be estimated only to within an order of magnitude using most of the correlations developed to date, and laboratory test situations are incapable of duplicating field situations (Lyman et al., 1982). Therefore, the consideration of dissociation effects may be unimportant, for this evaluation.

If scores based on both the BCF and the K_{ow} can be determined, preference should be given to the measured BCF values rather than those estimated based on K_{ow}.

PARAMETER SCORE	CRITERIA	
	BCF	log Kow
10	>15000	>6.0
7	>500 - 15000	>4.0 - 6.0
4	>20 - 500	>2.0 - 4.0
0	$\leq$ 20	$\leq$ 2.0

Suggested Information Sources

Lyman *et al.*, 1982 -
Contains BCF and K_{ow} data and estimation methods.

Geyer *et al.*, 1984 -
Examines relationship between BCF and K_{ow}.

Kenaga and Goring, 1980 -
Includes K_{ow} and BCF data for aquatic environments.

Verschueren, 1983 -
Includes BCF and K_{ow} data for organic substances.

Veith *et al.*, 1980 -
Includes BCF and K_{ow} values.

AQUIRE database -
Contains BCF data for aquatic organisms.

Mackay, 1982 -
Examines correlations of BCFs.

Garten and Trabalka, 1983 -
Contains BCF data for data for aquatic and terrestrial organisms.

ICF Inc., 1985 -
Includes BCF data.

Hansch and Leo, 1979 -
Describes how to estimate K_{ow} values.

2. Toxicity Parameters

Parameters "a" through "h" were selected to describe the toxicological properties of chemicals. Information on acute lethality of chemicals to all targets in the environment is included in parameter "a". The sub-lethal effects of chemicals on ecological systems (plants and animals) are described in parameters "b" and "c". Parameters "d" through "f" are primarily designed to describe potential adverse effects on human health.

When data are lacking on the effects of a chemical on a specific environmental target (e.g., humans, fish or wildlife) the best available information should be used. Unless specific data are available on species differences in responses to the chemical, it is assumed that all species respond in an equivalent manner and the most sensitive would be used in scoring. Differences in response among species, or other differences between experimental and "real-world" exposure situations (e.g., data from high level experimental exposures extrapolated to much lower levels) are not considered in this assessment.

There are several general topics, including route and duration of exposure and validity of testing procedures, that apply equally to all of the toxicity parameters. These are discussed below and will only be briefly referred to in the descriptions of each parameter.

Route of Exposure

Route of exposure is an important factor in the judgement of the applicability and validity of the effects observed under controlled experimental conditions (Grice, 1984; Willes et al., 1985). In terrestrial animals, oral, inhalation and dermal routes of exposure are considered the most representative of "real-world" exposures. In aquatic species, the usual route of exposure is through water. In plants, exposures usually occur through soils or from the atmosphere. In all test systems, data derived by direct application of chemicals to biological systems (e.g., direct injections into tissues) that by-pass normal absorption and uptake systems may indicate the potential for the production of adverse effects but their relevance to normal exposures should be carefully evaluated. In addition, the use of vehicles (e.g., dimethylsulfoxide) in dermal exposure studies can substantially increase the uptake of chemicals through the skin and, although the results would indicate a worst-case assessment of potential effects, their relevance to usual dermal exposure is questionable. In all of the toxicity elements the scorer must exercise judgement in the use of data derived from unusual exposure routes. If such data are the only information available they may be used, but, at the very least the scores assigned require appropriate "flags" (e.g., ? or ! or "e").

Duration of Exposure

The duration of exposure is important in the assessment of potential effects of chemicals on the environment and health (Hushon and Kornreich, 1984). Acute lethality is usually assessed following a single exposure (e.g., LD_{50}, LC_{50}), or following a short duration of exposure (e.g., acute tolerance tests or 96-hour LC_{50} tests in aquatic species). The assessment of long term effects usually involve multiple exposures for the major portion of the lifespan of the test system (FDA, 1982). This is usually considered a minimum of one year in terrestrial animals (FDA, 1982), but may be as short as a few days in certain short-lived aquatic and plant test systems.

In the assessment of long term effects of chemicals, judgement is required to determine if the duration of exposure and observation in the studies was adequate both to achieve a steady state level of the chemical in the system and to encompass the latency period for the development of adverse effects. The biological half-life of the test chemical can assist in judging whether steady state levels of the chemical in the test system were achieved. For example, a minimum of 3.5 half-lives are generally required to reach 99% of the steady state body burden (FDA, 1982; Willes et al., 1985).

The latency period between the initiation of exposure and the development of particular adverse effects depends on the type of effects produced, in addition to the time required to achieve a steady state body level. Effects related to general narcotic actions of chemicals generally have much shorter latency periods (e.g., several hours) compared to cancer where latency periods range from months to years (Grice 1984; Willes et al., 1985).

If adequate long term exposure data are not available, scores for toxicity elements addressing long term effects may be estimated from shorter term exposure data. In terrestrial animals, data from exposures of 90+ days may provide reasonable estimates of certain long-term effects, although the validity of extrapolating such data to predict chronic effects requires considerable judgement. Judgement is even more critical when estimates of potential chronic effects are made by extrapolation of data from various short-term in vivo or in vitro test systems (Grice, 1984; Willes et al., 1985). It is not possible nor desirable to overly complicate a scoring system by incorporating all the uncertainties of extrapolating data from shorter to longer exposure scenarios. Therefore, as a general rule, when effects related to long term exposure are estimated from short term exposure data, the scores derived require appropriate "flags" (e.g., l, ? or "e") indicating uncertainty in the assigned score.

Validity of Testing Procedures

The assignment of scores to the various toxicity parameters requires that the scorer assess the validity of the procedures followed in the collection of the toxicological data. It is beyond the scope of this scoring system to provide details of adequate procedures for the myriad of ever-changing tests available. The follwing references outline current standard procedures used in the collection of toxicological data: Grice et al., (1975); IARC (1980); FDA (1982); EPA (1984); NTP (1984); OSTP (1985). The validity of new testing procedures can usually be determined from publications by recognized authority centres around the world (e.g., Health and Welfare Canada, U.S. EPA, U.S. FDA, WHO, OECD, IARC).

(a) ACUTE LETHALITY

Rationale

This parameter describes the acute lethality of a chemical to terrestrial and aquatic animals. Non-lethal or reversible effects are not included in this element.

Acute effects other than lethality (e.g., irritation, allergic reactions, general narcosis, etc.) are considered in other toxicity elements. Criteria for phytotoxicity are not included in this element because of the difficulties in assessing lethality in plants.

Scoring Criteria

Scoring criteria for acute oral and dermal LD_{50}s and inhalation and aquatic LC_{50}s are similar to those utilized by the Transportation of Dangerous Goods Act (DOT, 1984) and the State of Michigan Critical Materials Registry (Michigan, 1979). Scores of six down to zero for oral and dermal LD_{50}s are comparable to the extremely toxic to relatively non-toxic scales outlined in the literature (Hodge and Sterner, 1949; Gleason *et al.*, 1977; Doull *et al.*, 1980). The criteria for scores of 8 to 10 would identify chemicals with greater toxicity than those included in the scales referred to above. These more stringent criteria were adopted to ensure chemicals with extreme acute lethality are clearly identified by the scoring system.

The scoring criteria for inhalation LC_{50}s are derived from the oral LD_{50} criteria, assuming a 60 kg individual respires 20 m^3 of air daily and that the contaminants have equal biological availability via the oral and inhalation routes of exposure. The aquatic toxicity LC_{50} data would usually be derived from 96-hour exposures.

Scoring criteria for this parameter are as follows:

PARAMETER SCORE	CRITERIA Oral LD_{50} mg/kg	Dermal LD_{50} mg/kg	Inhalation LC_{50} mg/m^3	Aquatic LC_{50} mg/L
10	$\leq$0.5	$\leq$0.5	$\leq$1.5	$\leq$0.1
8	>0.5 - 5	>0.5 - 5	>1.5 - 15	>0.1 - 1
6	>5 - 50	>5 - 50	>15 - 150	>1 - 10
4	>50 - 500	>50 - 500	>150 - 1500	>10 - 100
2	>500 - 5000	>500 - 5000	>1500 - 15000	>100 - 1000
0	>5000	>5000	>15000	>1000

Suggested Information Sources

ACQUIRE database -

This database contains acute lethality values for aquatic and terrestrial species.

Hayes, 1982 -

Contains information on the toxicology of pesticides and associated chemicals with particular reference to effects in humans.

Ketchen and Porter, 1979 -

These Critical Material Data sheets summarize information on the toxic potential of individual chemicals, including acute lethality data, in terrestrial species.

Merck Index -

The Merck Index lists indices of toxicity for many chemicals in terrestrial species.

MEDLINE database -

A computerized database presenting titles and abstracts of published, worldwide, biomedical literature.

Clayton & Clayton, 1981 -

Summarizes the toxic characteristics of a large number of industrial chemicals, primarily in terrestrial species.

(b) SUB-LETHAL EFFECTS ON NON-MAMMALIAN SPECIES

Rationale

This parameter describes potential effects from long-term exposures of non-mammalian species to chemicals. The effects-data may be expressed as median effect concentration (EC_{50}), maximum aquatic toxic concentration (MATC) or no-observed-adverse-effect-concentration (NOAEC).

The most frequently reported data of these types are EC_{50} values for fish or other aquatic organisms such as daphnia. Associated with an EC_{50} value is the species studied, the endpoint(s) observed, and the duration of exposure. Common endpoints are immobilization, loss of equilibrium, effects on reproduction and other sub-lethal effects. As with other parameters, if different indicators of effects are available, the most sensitive would be used, unless scorer judgement indicates otherwise.

As with mammalian toxicity, duration of exposure is important to the interpretation of the results. For aquatic organisms, either full or partial life-cycle tests are preferred for the assessment of reproductive effects. Such tests may last as few as seven days or extend beyond a year depending on the life cycle. For terrestrial animals, periods of exposure usually last several months. For other types of effects, results from 96-hour exposures generally have more credence than shorter exposures. In addition, preference should be given to tests on freshwater species native or introduced to North America.

Scoring Criteria

Based on published results of the effects of many substances on aquatic organisms, the NOAEC values that appear in the score definitions are a factor of 100 lower than EC$_{50}$ values (Konemann and Visser, 1983). Maximum Aquatic Toxic Concentration (MATC) values are 10 times lower than EC$_{50}$ values.

The scoring criteria for this parameter are as follows:

PARAMETER SCORE	CRITERIA - AQUATIC ORGANISMS	TERRESTRIAL ORGANISMS
10	EC$_{50}$ $\le$0.02 mg/L; OR MATC $\le$0.002 mg/L; OR NOAEC $\le$0.0002 mg/L in different genera.	Adverse effects at $\le$1 mg/kg for sub-chronic exposure OR $\le$0.5 mg/kg for chronic exposure, in different genera.
8	EC$_{50}$ $\le$0.02 mg/L; OR MATC $\le$0.002 mg/L OR NOAEC $\le$0.0002 mg/L in one genera only.	Adverse effects at $\le$1 mg/kg for sub-chronic exposure OR $\le$0.5 mg/kg chronic exposure, in one genus only.
6	EC$_{50}$ <0.2 - 0.02 mg/L; OR MATC <0.02 - 0.002 mg/L; OR NOAEC <0.002 - 0.0002 mg/L.	Adverse effects at >1-10 mg/kg for sub-chronic exposure OR >0.5-5 mg/kg for chronic exposure.
4	EC$_{50}$ <2 - 0.2 mg/L; OR MATC <0.2 - 0.02 mg/L; OR NOAEC <0.02 - 0.002 mg/L.	Adverse or non-adverse effects at >10-100 mg/kg for sub-chronic exposure OR >5-50 mg/kg for chronic exposure.
2	EC$_{50}$ <20 - 2 mg/L; OR MATC <2 - 0.2 mg/L; OR NOAEC <0.2 - 0.02 mg/L.	Adverse or non-adverse effects at >100-1000 mg/kg for sub-chronic exposure OR >50-500 mg/kg for chronic exposure
0	EC$_{50}$ $\ge$20 mg/L; OR MATC $\ge$ 2 mg/L; OR NOAEC $\ge$0.2 mg/L.	Adverse or non-adverse effects at $\ge$1000 mg/kg for sub-chronic exposure exposure, $\ge$500 mg/kg for chronic exposure.

Suggested Information Sources

AQUIRE database -

AQUIRE has EC_{50} and/or NOAEC data for aquatic organisms for some organic chemicals.

Most information required for this element must be sought from primary sources identified through literature searches.

(c) SUB-LETHAL EFFECTS ON PLANTS

Rationale

Sub-lethal effects on plants are highly varied depending on the toxicant. The relative significance of the injury or effect depends on the commodity and its use. These can be divided into three categories.

A The appearance is important, but growth and yield are of much less importance. This is relevant for ornamentals, flower crops, leafy vegetables and fruit.

B The impact on growth and yield are the most significant, and visible injury to the foliage, though unsightly, is of less importance. This is relevant for vegetables, fruits, seeds and storage organs such as tubers.

C There are no visible injurious effects but thr longevity of the commodity has been altered. This is of greatest significance in flower crops and storage of fruit and vegetables.

The toxic effects can generally be assayed using short term tests with indicator plants. The possible effects include a wide spectrum of responses: inhibition of germination, inhibition of seedling growth, growth abnormalities, reduction in either root or shoot growth, etc. Long term tests with annual plants may be used to assess chronic effects such as decreased yield or decreased competitiveness (NAS, 1975).

The most commonly tested aquatic plants are algae and duckweed (Lemna minor) (U.S. EPA, 1978). Several test methods have been developed that use algae (for example, the U.S. EPA Algal Assay Bottle Test). Duckweed has been used to assess the effects of substances on aquatic macrophytes, (EPA, 1978).

Effects on the genetic make up of the organism may be assayed using other short term tests with plant material. These include gene mutations, DNA repair, primary DNA damage and chromosomal abberations (Sandhu, 1980). Some examples of genetic mutation assays using plants are the measurement of chromosomal aberrations in root tip cells, the Tradescantia micronucleus assay

(Sandhu, 1980) and the use of Arabidopsis for measuring the frequency of mutational events at the embryo stage (Redei, 1980).

Scoring Criteria

The score definitions for aquatic plants are very similar to those used in parameters which address sub-lethal effects on aquatic animals.

Various biomonitors have been used for different contaminants with each species displaying characteristic symptoms for a given pollutant. Some of these tests have been standardized to a substantial degree while others are only qualitative indicators. Standardized sampling methods have also been devised for substances that accumulate in vegetation and that are toxic to animals. Lichens are also used for a variety of contaminants, both as indicators by presence or absence, or are used as accumulators.

Standardized tests have been reported for relatively few substances. In some cases, the scoring system can accommodate results expressed in concentration units (mg/L for substance in water, ug/m^3 for gaseous contaminants, and mg/kg for substances in the soil), but in most instances, the length of exposure time is very important. It is thus necessary to link the persistence or the number of releases or the length of exposure to this element in some way through the use of appropriate combining rules.

Precautions. Soil extraction procedures are critical in determining the level of a toxicant, e.g. the total amount removed by acid extraction may no be meaningful in relation to plant bioavailability.

The scoring criteria for this element are as follows:

ELEMENT SCORE	CRITERIA				GENERAL NARRATIVE
	AQUATIC PLANTS		TERRESTRIAL PLANTS		
	EC_{50}	NOAEC	EC_{50}	NOAEC	
10	$<0.01_w$	$<0.001_w$	$<0.01_w$ $<10_a$ $<0.1_s$	$<0.001_w$ $<1_a$ $<0.01_s$	Irreversible dysfunctional pathological effects
8	$0.01-0.1_w$	$0.001-0.01_w$	$0.01-0.1_w$ $10-100_a$ $0.1-1_s$	$0.001-0.01_w$ $1-10_a$ $0.01-0.1_s$	Reversible dysfunctional pathological effects
6	$>0.1-1_w$	$>0.01-0.1_w$	$>0.1-1_w$ $>100-1000_a$ $>1-10_s$	$>0.01-0.1_w$ $>10-100_a$ $>0.1-1_s$	Degenerative reversible effects slightly disfunctional
4	$>1-10_w$	$>0.1-1_w$	$>1-10_w$ $>1000-10000_a$ $>10-100_s$	$0.1-1_w$ $>100-1000_a$ $>1-10_s$	Reversible effects, not dysfunctional
2	$>10-100_w$	$>1-10_w$	$>10-100_w$ $>1\times10^4-1\times10^5{}_a$ $>100-1000_s$	$>1-10_w$ $>1000-1\times10^4{}_a$ $>10-100_s$	Reversible effects such as enzyme induction and sub-cellular effects
0	$\geq 100_w$	$\geq 10_w$	$\geq 100_w$ $\geq 1\times10^5{}_a$ $\geq 1000_s$	$\geq 10_w$ $\geq 1\times10^4{}_a$ $\geq 100_s$	No effects measurable

$_w$ = concentration of substance in water in mg/L
$_a$ = concentration of substance in air in mg/m^3
$_s$ = concentration of substance in soil in mg/kg

Suggested Information Sources

Manning and Feder, 1980-
Discusses the use of plants as monitors of pollution.

Lepp, 1981 -

Discusses effects of heavy metals in plants.

Martin and Coughtrey, 1982 -

Discusses effects of heavy metals on biota as indicatators of pollution.

NRCC -

Publications of the Associate Committee on Scientific Criteria for Environmental Chemistry includes data on effects on plants.

Levitt, 1980 -

Reviews environmental stress on plants.

Ormrod, 1978 -

Reviews effects of pollution on horticulture.

Information will have to be sought from primary sources for many of the toxicants.

(d) SUB-LETHAL EFFECTS ON MAMMALS

Rationale

This parameter describes potential longer-term effects of chemicals in mammals. The effects are directed primarily at human health, although the actual data used will largely be from laboratory animals. Other scoring systems (see Hushon and Kornreich, 1984) generally score chemicals for sub-lethal toxicity based on specific effects (e.g., separate scores for carcinogenicity, mutagenicity, teratogenicity, etc.), but most do not address systemic toxic effects. The toxic effects included in this parameter are restricted to sub-lethal systemic effects, but do not include carcinogenic, mutagenic or teratogenic effects since these are included in other parameters.

Scoring Criteria

If data are not available on the effects following a suitable duration of exposure, either appropriate "tags" (!, ? or e) should be used, or, preferably, the criteria should be divided by an appropriate extrapolation factor to adjust for potential effects that would not develop during shorter exposure studies. Criteria used in the development of scores for this parameter would be derived from sub-chronic (generally 90-day exposure) or chronic (usually 1 year or more) exposure studies in any mammalian species (refer to the general discussion of exposure duration). If the data were derived from sub-chronic studies, it is recommended that the NOAEL be divided by a 10-fold extrapolation factor (see FDA, 1982; Dourson and Stara, 1983). If the only data available involved even shorter term exposures (e.g., 14 days), it is recommended that a 100-fold extrapolation factor be used. Considerable judgement will be required in the utilization of such extrapolation factors, considering issues such as the biological half-life of the chemical, the biological characteristics of the test system from which the data was derived, and knowledge of the usual consequences of the type(s) of lesions produced.

The scoring criteria for this parameter do not provide for differences in the type of toxic response observed. For example, if the effects associated with exposure are irreversible, the consequences of exposure are much more serious than if the effects reverse following cessation of exposure. For the purposes of this assessment, all effects are considered as equal but details of differences in the severity of the effects would be carefully noted.

Examples of the various end-points included as chronic systemic effects are as follows:

Reproduction toxicity - Adverse effects on reproduction as they affect the survival, development and well-being of the species, including interference with gonadal functions but excluding teratogenic effects.

General toxicity - General depressions in body weight and body weight gains, general behavioural alterations and increases in diseases secondary to chemical exposure.

- Gross or microscopic alterations indicative of disease from toxic events.

- Adverse or deleterious effects on organ systems or functions, alterations in secretions of exocrine and endocrine glands, alterations in the brain and peripheral nervous systems.

- Treatment related biochemical effects.

If data are available on more than one of these effects, the effect occurring at the lowest exposure level in the most sensitive test system should be used in scoring. In addition, structure-activity relationships may provide estimates of the occurrence of chronic effects if data on the actual compound are lacking. Structure-activity relationships appear reasonably predictive for certain types of effects (e.g., narcotic effects), however, little predictive value is obtained for other effects using available methods. In the future, the accuracy of structure-activity relationships in predicting effects between different chemicals may improve. Even with present methodologies, however, an estimation of potential effects may prove more valuable than accepting a judgement of inadequate information. Such estimates, however, would be appropriately "flagged" with a ? or "e".

The scoring system for this parameter is as follows:

PARAMETER SCORE	CRITERIA[1] ORAL NOAEL mg/kg	INHALATION NOAEL mg/m^3
10	≤0.1	≤0.3
8	>0.1 - 1	>0.3 - 3
6	>1 - 10	>3 - 30
4	>10 - 100	>30 - 300
2	>100 - 1000	>300 - 3000
0	>1000	>3000

[1] Criteria are based on data from exposures of 1 year or more in duration. If data from studies of 28 to 90-days exposure are used, divide all scoring criteria by 10. If data from 14-day studies are used, divide all scoring criteria by 100.

Suggested Information Sources

Most of the information on the toxic effects associated with chronic exposure to chemicals would be obtained from original scientific publications which could be accessed through the MEDLINE and TOXLINE databases. Additional sources of summary data include Ketchen and Porter (1979), Clayton and Clayton (1981), RTECS database, and Verschueren (1983). It should be emphasized however, that the judgement of the validity of a NOEL from summary data is difficult and that original publications should be consulted.

(f) TERATOGENICITY

Rationale

This parameter describes the potential teratogenic effects of chemicals on mammalian systems. Toxic effects on reproduction in plants, non-mammalian and mammalian systems, as distinct from developmental defects, are described in parameters b, c, and d. The production of terata by exposure to chemical contaminants can seriously compromise the development and survival of offspring. Such effects are usually irreversible, although current understanding is that they have an exposure threshold (EPA, 1984).

The criteria for these effects are as outlined by the U.S. Environmental Protection Agency (EPA, 1984). Teratogenic effects include frank developmental malformations detrimental to the survival, future development, or well-being of newborn. They do not include developmental anomalies and aberrations that appear to be secondary to embryo-, feto- and maternal toxicity (see EPA, 1984; Khera, 1981). Many such effects are known to recover as development proceeds (e.g., reversible delayed ossification of various parts of the skeleton, delayed development of specific organs, delayed eye opening, delayed vaginal opening, reduced body weight) (Khera, 1981). In some cases, exposure of pregnant females to chemicals can result in malnutrition due to decreased feed intake. Malnutrition has been shown to delay embryo and fetal development, reduce birth weights and, in severe cases, produce irreversible neurological and metabolic abnormalities (EPA, 1984; Khera, 1984). These differences in the apparent severity between frank terata and minor developmental anomalies from chemicals are reflected in the scoring criteria for this element.

Behavioural teratology is a rapidly developing sub-field of teratology and includes effects related to alterations in the behaviour of the offspring as they mature. In some cases behavioural effects may not be evident until maturity (e.g., effects on sexual behaviour). Other effects may only be temporary and actually disappear at some later stage of development. No specific criteria have been included in this parameter for behavioural teratogenic effects and judgement must be exercised to determine how such effects "fit" into the criteria provided. As the significance of such effects is better understood, alterations in the criteria for this parameter may be required to encompass the increase in knowledge.

Scoring Criteria

Working from the assumption that teratogenic effects exhibit exposure thresholds (Khera, 1981; EPA, 1984), scoring criteria are based on gradations in exposure levels associated with effects. Since teratogenic effects are viewed as more serious than developmental anomalies as outlined above, higher scores are applied to chemicals showing evidence of frank teratogenicity. Chemicals producing developmental anomalies and aberrations are assigned lower scores (e.g., delayed ossificaton of bone, decreased fetal weights, decreased birth weights, prolonged gestation, decreased survival without abnormalities, developmental effects that reverse during postnatal development).

Duration of exposure is particularly critical in assessing teratogenic effects. To adequately assess the potential for such effects from a chemical exposure should occur at least through the period of organogenesis (e.g., usually from late in the first trimester through early in the third trimester of gestation). In addition, the levels of exposure studied should be sufficient to elicit a range of effects in the dams, from toxicity at the higher exposures to no-observable effects at the lower exposures (Grice et al. 1975; EPA, 1984; Khera, 1981).

The general requirements regarding route of exposure discussed earlier also apply to teratogenicity assessments.

The scoring criteria for this parameter are as follows:

PARAMETER SCORE	CRITERIA
10	- Teratogenic effects observed without overt maternal toxicity at maternal exposures ≤0.1 mg/kg/day during organogenesis, or equivalent exposure[1]
8	- Teratogenic effects observed without maternal toxicity at maternal exposures >0.1 - 1 mg/kg/day during organogenesis or equivalent exposure
6	- Teratogenic effects or developmental anomalies observed at maternal exposures >1 - 10 mg/kg/day during organogenesis or equivalent exposure
4	- Teratogenic effects or developmental anomalies observed at maternal exposures >10 - 50 mg/kg/day during organogenesis or equivalent exposure
2	- Teratogenic effects or developmental anomalies obsreved at maternal exposures >50 - 1000 mg/kg/day during organogenesis or equivalent exposure
0	- No terata observed at maternal exposures ≥1000 mg/kg/day or equivalent exposure

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[1] Equivalent exposure by inhalation or dermal routes, assuming effects by dermal exposure would occur at comparable doses to oral exposure and that the total dose by inhalation is equivalent to oral exposure based on a 60 kg adult respiring 20 m^3 of air daily. These assumptions mean that the dermal and oral exposure levels are equivalent, and inhalation exposures (in mg/m^3) are obtained by multiplying the oral exposure by three.

Information Sources

Most of the information on the teratogenic effects associated with exposure to chemicals can be obtained from original scientific publications which can be accessed through the MEDLINE and TOXLINE databases. Additional sources of summary data include Ketchen and Porter (1979), Clayton and Clayton (1981), RTECS database, and Verschueren (1983). Care should be exercised in using the RTECS date base since only studies showing positive effects associated with exposure are reported. It must also be emphasized that the judgement of the validity of teratogenic effects (e.g., the evaluation of frank developmental anomalies versus developmental aberrations) from summary data is difficult and that original publications should be consulted.

GENOTOXICITY/MUTAGENICITY

Rationale

This parameter describes the mutagenic and genotoxic potential of a chemical. Such effects in themselves are indicative of potential hazards of chemicals to health and the environment. In addition, the strength of such evidence is valuable in the interpretation of other potential hazards from chemicals (e.g., carcinogenicity).

Genotoxic or mutagenic effects on somatic or germ cells are considered equal potential hazards. Evidence of heritable mutations (i.e., mutations in germ cells) was regarded as more indicative of the test system studied and ability of a chemical to distribute to germ cells (i.e., the disposition of the chemical in vivo) ra her than of a greater potential hazard. In addition, assessment of the potential for germ cell mutations requires specific tests (e.g., dominant lethal test, mouse heritable translocation assay) and results from such tests are not available for large numbers of chemicals. Therefore, specific scoring criteria for germ cell mutations would increase the dependency of the resulting prioritization of chemicals on the information available rather than indicators of potential hazard. In the scoring criteria used, chemicals for which evidence of germ cell mutations are available would receive high scores, however, not preferentially higher than chemicals with evidence of somatic mutations only.

Scoring Criteria

The criteria assign higher scores to chemicals with adequate evidence of mutagenic/genotoxic effects derived from short-term tests. The primary objective is to score the potential of a chemical to produce such effects.

Chemicals producing direct mutagenic/genotoxic effects in the absence of overt toxicity are assigned the highest scores (e.g., the chemical or its activated metabolite(s) directly acts on genetic material to produce mutations or genotoxic effects). Clastogenic effects produced by chemicals that do not directly interact with genetic material are scored in the next category. Chemicals causing mutagenic or genotoxic effects indirectly by interfering with various cellular systems would receive lower scores. Scores of two or four should be assigned to chemicals having positive evidence from certain test systems but clear evidence of lack of effects in other test systems.

It is assumed that all test data will be derived under optimal experimental conditions (e.g., using validated test procedures, including appropriate S-9 metabolic activating systems, adequately controlling for unusual chemical/physical characteristics of the test chemicals). Acceptable tests include, but are not necessarily limited to, the following:

a) _in vitro_ gene mutation

- _Salmonella_/mammalian microsome assay
- CHO/HGPRT - assay
- L5178Y TK - assay
- Haploid _Saccharomyces_ assay

b) _in vitro_ mammalian chromosomal aberrations

- metaphase analysis in mammalian cells exposed _in vitro_ (not including sister chromatid exchange and micronuclei)

c) _in vivo_ mammalian chromosomal aberrations

- rodent bone marrow micronucleus assay
- rodent bone marrow metaphase analysis (not including sister chromatid exchange)

d) _in vivo_ mammalian gene mutation or indicator tests in a second somatic tissue

- rodent liver unscheduled DNA synthesis
- rodent sister chromatid exchange

Data from other tests may be used with appropriate justification. There will be many chemicals for which adequate information for this parameter is lacking or incomplete. The use of structure-activity relationships in developing scores for this parameter may be a viable alternative in the future, however, at present such concepts are only in their formative stages (FDA, 1982; NTP, 1984; OSTP, 1985) Consequently, considerable expertise and judgement are required to assign scores based on structure-activity information, and such scores would require appropriate "flags" to signify the level of confidence in the data used (e.g., !, ?, e).

The scoring criteria for this parameter are as follows:

PARAMETER SCORE	CRITERIA
10	Conclusive evidence of mutagenicity or genotoxicity in recognized prokaryotic or eukaryotic test systems at exposure levels not producing overt toxic effects
8	Evidence of clastogenic effects (general DNA damage, strand breaks, sister chromatid exchange), intercalations or crosslinks but no evidence of increased incidences of mutations or direct interactions with genetic material
6	Does not interact directly with DNA, but interferes with cellular mechanisms such as DNA synthesis and DNA repair. Effects may be observed at exposure levels associated with overt toxicity unrelated to genetic effects
4	Mutagen/genotoxin in prokaryotic systems only (i.e., data from eukaryotic test systems are negative).
2	Mutagen/genotoxin in _in vitro_ systems only (i.e., data from _in vivo_ systems are negative).
0	No evidence of mutagenic or genotoxic effects in a adequate battery of test systems.

Suggested Information Sources

Information on the genotoxicity/mutagenicity of chemicals would generally be obtained from original publications and review articles as identified through MEDLINE or TOXLINE databases or through the GenTox Information Service. Information may also be available from various summary data sources including Bowman (1982), Fairchild (1978), Fishbein (1979), Ketchen and Porter (1979), Kirsch-Volders (1983), Sax _et al_. (1981), Soderman (1983), Sontag (1981), and Stich and San (1984). It is difficult to judge the validity of genotoxicity/mutagenicity tests from summary data, however, and original publications should be consulted where possible.

(g) CARCINOGENICITY

Rationale

This parameter describes the potential of chemicals to cause cancer. Detailed assessment of the dose-response relationships, types of cancers produced, the validity of extrapolating carcinogenicity data among species and the processes of risk identification, assessment and management are beyond the sophistication of this assessment.

There is general agreement that radiation, biological, physical and chemical agents can cause cancer. In addition, the biochemical and molecular process of cancer development, as it is understood, is similar among mammalian species (NTP, 1984; OSTP, 1985). It is evident that the development of cancer is a multi-stage process involving interactions of agents with genetic material (the genome). The induction of tumorigenic phenotypes through interactions with the genome may occur directly through the induction of somatic mutations or indirectly by alterations in gene expression. A number of factors affect the occurrence of these events, including age, sex, genetic differences, strain and species differences, diet, dose rate, route of exposure, interactions with other agents and a variety of environmental conditions (NTP, 1984; OSTP, 1985). Furthermore, the production of these effects by a chemical may be by direct action of the chemical or its metabolites (e.g., direct acting, genotoxic carcinogens) or indirect through actions of the chemical on systems that secondarily produce tumorigenic phenotypes (e.g., non-genotoxic or epigenetic mechanism). Although the detailed mechanism(s) of cancer production are not fully understood, it is evident that once the required modification in the genome occurs (known as initiation), the process is irreversible and self-propagating. A wide range of factors affect the initiation process, however, and many of these are believed to be reversible (IRLG, 1979; NTP, 1984; OSTP, 1985).

Although the exact mechanisms of the various stages of carcinogenesis are not fully understood, it is apparent that the events leading to the initiation of cells are dose-related (i.e., the frequency of occurrence of initiation increases with exposure). Once initiation has occurred, however, the subsequent development of tumours is independent of the exposure level (IRLG, 1979). This information is important to the scoring of the carcinogenic potential of a chemical.

Based on this brief summary of what is known about the process of carcinogenesis (refer to IRLG, 1979, NTP, 1984 and OSTP, 1985, for more detailed discussions), the scoring criteria for this element differentiate between direct acting and indirect acting carcinogens. It is important that the scoring system not merely reflect the completeness of the data base (e.g., only a few chemicals have been adequately studied from an epidemiological point of view in human populations to assess their carcinogenicity). For many chemicals, epidemiological studies to assess their carcinogenic potential will never be conducted and complete reliance will have to be placed on animal bioassay data for their evaluation. If the data from animal bioassays are viewed sufficiently strong, "epidemiologically proven" and "potential human" carcinogens (i.e, positive in animal bioassays) are given equal weight in the scoring system.

Scoring Criteria

The following definitions of carcinogenicity are used in scoring this parameter (Tomatis, 1979):

- Evidence of carcinogenicity is positive when an increase in malignant tumours is caused in more than one species or strain, in multiple experiments with varying routes or levels of exposure or to an unusual degree with respect to type, site, incidence or latency period.

- Evidence of carcinogenicity is negative when no tumour induction is observed in at least two adequate and appropriate animal studies in different species or in both animal and epidemiology studies.

- Evidence of carcinogenicity is inconclusive when neither of the above two conditions apply, usually because the observations are inadequate, of unacceptable quality or excessively limited. Contradictory results from different test systems may also lead to an inconclusive assessment. Such conditions are recorded as either positive or negative for carcinogenicity and tagged with either a ? or I depending on the interpretation of the information by the scorer.

There is a great deal of controversy regarding the potency ranking of carcinogens, particularly when attempting to denote the potency of a chemical to cause cancer in man from data derived from animal cancer bioassays. Animal bioassays utilize high exposure levels (known as the Maximum Tolerated Dose or MTD protocol, see NTP, 1984; OSTP, 1985). Judgements of carcinogenic potency based on information derived from such high levels of exposure may have little relationship to potencies at lower levels of exposure comparable to those found in the environment. Consequently, the basis for potency ranking is not considered adequately developed for use in a scoring system. However, if procedures for such ranking were found reliable, they would form a reasonable basis for the scoring of the carcinogenic potential of chemicals.

Important information to assist in the interpretation of animal cancer bioassay data vis-a-vis the potential of a chemical to cause cancer in humans can be derived from assessments of its mutagenicity/genotoxicity.

The scoring scheme for this parameter is as follows:

PARAMETER SCORE	CRITERIA
10	Direct acting human carcinogen or potential human carcinogen (based on animal bioassay data) with evidence of direct interactions with genetic material. Acts as an electrophile or direct alkylating agent, produces DNA adducts, induces cell transformation, etc.
8	Indirect acting human carcinogen or potential human carcinogen (based on animal bioassay data) with evidence that it does not interact with genetic material
6	Carcinogenic in animal bioassay tests at levels of exposure shown to saturate enzymes involved in the metabolism of the compound or at exposure levels shown to cause histopathological lesions known to predispose animals to the development of cancers at sites where the lesions are observed (e.g., ATPAse deficient liver foci in rodents). Adequate evidence must be available demonstrating that no interactions occur with genetic material and that the chemical does not induce cell transformation.
4	Positive tumorigenic agent (benign tumours) in humans or animals. Evidence must be available of lack of interactions with genetic material. Includes chemicals that act solely as promoters and those that cause cell transformation *in vitro* without evidence in other systems
2	Tumorigenic in only one animal species and negative in other(s) (all studies considered adaquate)
0	Not tumorigenic in an adaquate animal bioassay in at least two species and must not interact with genetic material

Information Soerces

Information on the carcinogenicity of chemicals would generally be obtained from original publications and review articles as identified through IARC Monographs or MEDLINE, TOXLINE databases or National Toxicology Program (NTP) publications. Information may also be available from various summary data sources including Bowman (1982), Fairchild (1978), Fishbein (1979), Ketchen and Porter (1979), Kirsch-Volders (1983), Sax *et al* (1981), Soderman (1983), Sontag (1981), and Stich and San (1984). However, it is difficult to judge the validity of carcinogenicity data from summary data and original publications should be consulted.

APPENDIX B

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